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Enterprise Network Architecture

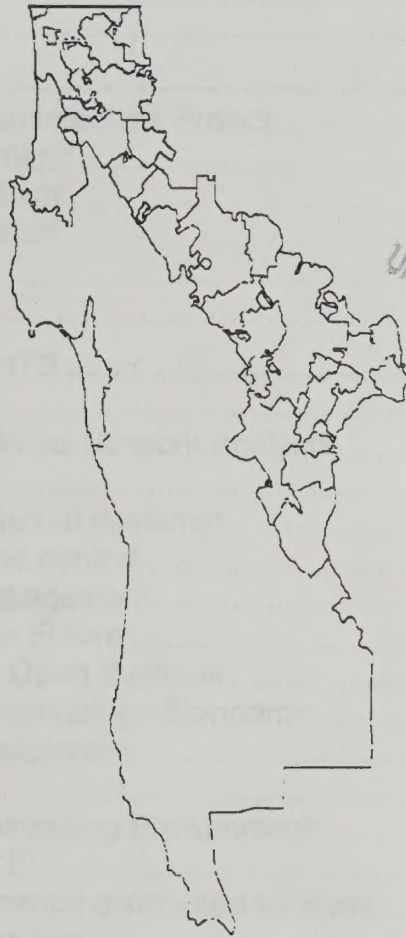
Enterprise Network



Fleming & Associates Consultants

County of San Mateo

Enterprise Network Architecture Strategic Design



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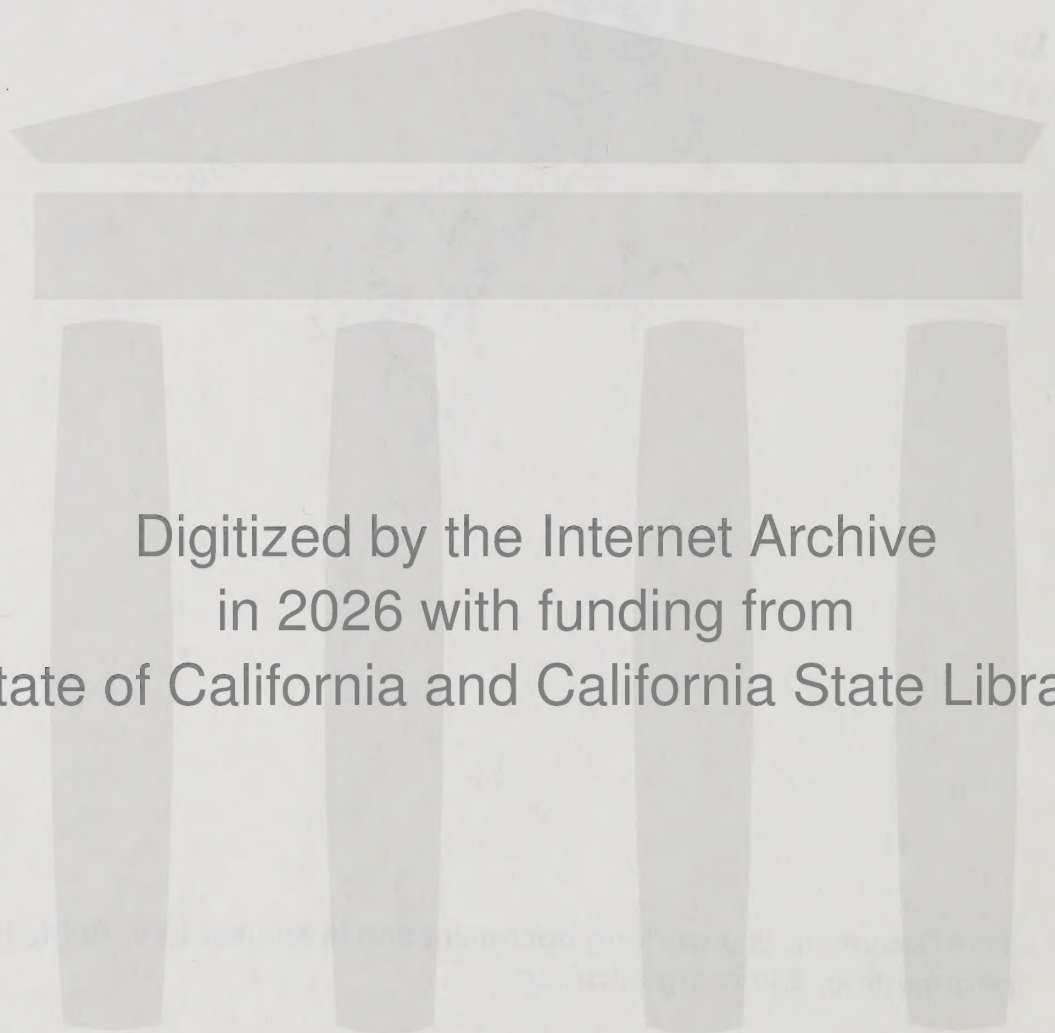
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EXECUTIVE SUMMARY

The current County-wide Telecommunications Network is based upon an IBM System Network Architecture, a proprietary, non-routable, connection-oriented, centrally controlled communications architecture. Dispersed throughout the County are pockets of Local Area Networks using a variety of network operating systems, and hardware.

This Infrastructure environment does not inter-operate easily. Providing network solutions for business needs require major expenditures and are very slow to develop. The network perpetuates the perception that ISD technical staff are not responsive, and do not have the experience and expertise to move the County into the next phase of technical development.

To direct network development away from the current IBM network environment and toward a non-proprietary, routable, distributed network a project was initiated within ISD to develop a strategic network migration plan. This plan described here in this document is called the Enterprise Network Architecture project.

This plan initiates a new direction for network design, based on the business needs of the departments. It is a flexible network, capable of customizable, local applications and module sized growth to meet the budget and the staff needs of the departments.

This plan focuses on significant recommendation number three (3), of the Deloitte & Touche study and Grand Jury recommendation, to **Develop a county-wide Telecommunications Infrastructure**.

The Enterprise Network Architecture Strategic plan also includes the Deloitte & Touche recommendations to:

- "Develop System Standards"
- "Develop a Migration Plan" (Strategy)

The purpose of the Enterprise-wide Network Architecture is to develop a strategic network architecture that is a county-wide **Telecommunications Infrastructure Design Model**.

This project has identified two objectives in designing the conceptual network model:

- Develop a network to accomplish the desired business objectives while realizing an overall cost saving over current technological solutions.
- Enhance current levels of user-perceived quality, for all traffic media.

These objectives are both addressed in providing for the inevitable growth in distributed LAN and client/server based networks in the County of San Mateo.

Develop System Standards:

The County of San Mateo Enterprise Network Architecture is a conceptual design is based upon a standard set of specifications. The County departments are in the process of developing plans to modify their local area networks. These changes are

moving the County toward newer technology that will allow inter-connection of various departments, and more flexibility in the use of software, data, and hardware.

Network specifications are basis on which department managers can develop their local networks and keep them consistent with inter-connection, and inter-operable requirements. These specifications are partially developed by the department business needs and partially by work done by standards organizations such as the Open Software Foundation (OSF), International Organization for Standardization (ISO), and de-facto industry standards.

These standards are called **Open System Standards** and create the basis upon which manufacturers provide for inter-connectivity and inter-operability in a distributed computing network.

Standardization based upon open systems take place at each of three levels:

- *Standard hardware and software platforms*
- *Standard applications*
- *Middleware*

Projects such as enterprise networking generally is a form of downsizing. Downsizing means a transition from mainframes to PC based workstations on distributed local area networks. This kind of downsizing also requires various diverse network systems to work smoothly together.

Downsizing allows the computing environment to grow or contract as the needs of the business change. The computing power is transferred from the centralized mainframe to the distributed desktop computer. These desktop computers are connected together in local area networks. Then connected together through a special Wide Area Network, called an Enterprise Network, designed to accept local area network traffic and route it efficiently to other local area networks.

This network transfers the computing power to the desktop, as a department grows by adding workstations, the computing power of the department and the entire network grows proportionately. This provides better control of budget expenditures as well. Development budgets can be sized to meet the network demands of the local department based on actual workstation and network needs.

The enterprise network architecture plan includes elements supporting the direction of downsizing to a distributed computing network:

- Distributed client/server based on Intel and/or UNIX platforms using an open operating system and local area networks with Enterprise Network protocols.
- Router/Hub/Network Switch, that inter-connect local area networks seamlessly to the Enterprise Network.
- A platform to manage distributed computing and enterprise networks, based on "Simple Network Management Protocol" the de-facto industry standard for network management.

Migration:

The county is not ready to make the financial and organizational commitment of converting wholesale to an Open System single protocol based distributed network. The cost is prohibitive, and the payoff is uncertain.

The practical scenario for the county is that open distributed systems will increasingly coexist within the county's existing enterprise network, sharing their assets with PCs and larger systems. The mix will include Intel-based systems running MS DOS (with or without Windows), Windows NT, Windows 95, OS/2; RISC systems from Sun, HP, IBM, Digital, and others running varieties of UNIX; and various proprietary computers with operating systems like MVS and VM.

SNA traffic will not likely disappear in the near term, and most likely will play a long term role in the County network Architecture for some mission critical data/applications.

The de-facto communications industry standard for transmission protocols on an Enterprise Network is Transmission Control Protocol/Internet Protocol (TCP/IP). TCP/IP is the data language used on the world-wide Internet, and is actually a suite of protocols developed by the Department of Defense in the 1970s to support construction of world-wide networks.

The County of San Mateo has already begun to migrate toward TCP/IP networking with the inter-connection to the Internet Superhighway. This migration will continue as departments interconnect to the County-wide Enterprise Network. Using this protocol as the standard ensures compatibility between diverse networks and allows them to inter-connect and inter-operate.

Manufacturers use the TCP/IP protocol as the standard in designing new networking equipment. This protocol also provides the primary addressing scheme for inter-networking enterprise-wide distributed systems.

The first phase of migration for the County toward a TCP/IP based network is to continue to build upon the TCP/IP network installed to support the Financial Management System. This network initially provides inter-connectivity for financial data networks on its own data channels, while SNA data, voice, and radio, continue on individual channels through the County-wide area digital Microwave network.

This will allow network design staff to design TCP/IP network paths to inter-connect diverse systems throughout the County. This connects departments and network elements together, providing EMail, data exchange, remote printing, and remote file access.

As demands for voice, data, and radio, increase, the need for more bandwidth will inevitably increase as well. This demand will eventually drive the usage of bandwidth beyond the capacity of the network to provide individual channels for each protocol type.

The next phase of the migration toward an Enterprise Network would require integration of Novell networks (IPX Protocol), IBM (SDLC Protocol), and DEC (LAT Protocol) into

the TCP/IP data stream. This is accomplished by protocol translation at the interface of the Enterprise Network.

Integration of SNA into TCP/IP will be necessary for future implementation of the Enterprise Network Architecture strategy for the County. SNA encapsulated in IP supports non-disruptive high-performance route switching.

In the interim, as the County increases the TCP/IP environment throughout the County it will be necessary to begin integration of SNA traffic into the TCP/IP traffic flow. This will simplify the network and provide for routable SNA traffic over the same channels used by the TCP/IP traffic, thus reducing bandwidth usage.

This also continues the County migration to open systems technology throughout the network. The process of encapsulation of SNA-SDLC traffic in IP data packets through routers is called SDLC tunneling.

This will allow all data traffic to use the same channel through the County-wide network. Voice and Radio would continue to use separate channels for County-wide connectivity.

The final phase of integration of the Enterprise Network will get the most from the available bandwidth (channels) available on the County-wide network. At the time the network approaches capacity it will be re-configured to support the Asynchronous Transfer Mode (ATM) protocol by replacing the routers at key locations with ATM switching technology.

ATM is a set of developing standards and technologies for switching information in fixed-length cells over high-speed lines. ATM supports integrated data, voice, and video in a broad range of environments, including desktops, wiring closets, enterprise switches, and carrier central offices.

ATM provides bandwidth compression from individual channel assignments improving bandwidth usage and providing integration of data, voice, and video on the same channel.

ATM's appeal is its capability to operate over local area networks, wide area networks at speeds from T1, to tens of megabits per second, or gigabits per second. With the migration strategy of a router based mesh network the County will be well positioned to take advantage of this technology when needed.

Wide Area Backbone Network:

The goal of the County-wide Enterprise Network Architecture is to provide connectivity among County agencies over digital data network links (paths). This produces a communications infrastructure improving the capability of County employees to share information, hardware, and software, for coordination of activities.

Initially, the basis of this topology is a TCP/IP backbone network connected through router-based mesh network providing better information transfer rates, redundant paths for better reliability, and the capability to add new locations easily.

Additionally, this topology reduces the complexity of the existing multiple protocol, disparate, networks by standardizing on industry accepted protocols. These technologies support the County goal of open systems inter-operability, portability, and inter-connectivity across the County.

To build this topology the analog Microwave network will require upgrading to digital Microwave systems as outlined in the Warner Group County-wide Telecommunications Strategic Plan. A current project to upgrade the Public Service Radio systems may implement an upgrade project for the Microwave system to digital County-wide.

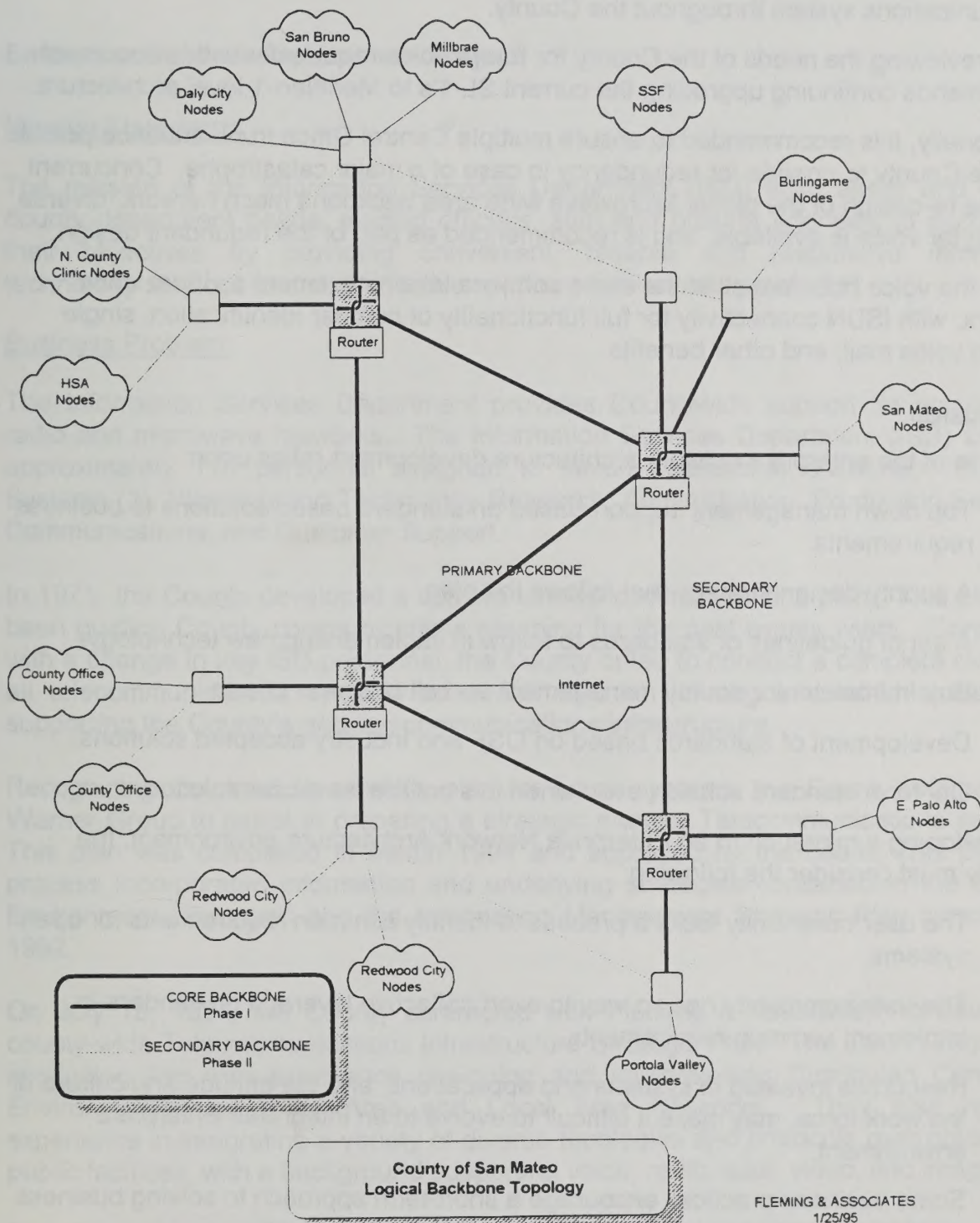
The topology is based on extending the existing digital Microwave network to close the loop at the north end of the County. This is partially accomplished by the North County Clinic project. In adding that location, there is a requirement to connect the North County Clinic, North County Court, and North County HSA together for communications services. A new Microwave link is planned to Sign Hill from the North County Court to connect into the County digital Microwave network.

Leveraging on the existing Microwave backbone network, the County has the capability to build a primary digital Microwave loop for the County Enterprise Network Architecture. Eventually, this loop could be upgraded to DS3 (45Mbps), or 28 T1's per path.

Using the Microwave backbone as the primary path for the Enterprise Network Architecture the County leverages on existing investment in technology, uses existing trained staff, and has retained experience to support the system.

By expanding this backbone into a highbred mesh network the County has created a reliable, routed, high-speed network capable of sustaining the needs of the County for many more years.

The following diagram shows a logical topology of this network strategy, the redundancy, and diversity, capable of providing reliability and alternate routing in emergency situations.



Voice Migration:

The Voice systems consist of Northern Telecom SL-1 and Meridian-1 telephone switches installed throughout the County generally function efficiently with few operational problems. The current voice network provides a robust, reliable voice communications system throughout the County.

Upon reviewing the needs of the County for future voice requirements this document recommends continuing upgrading the current SL-1's to Meridian-1 level architecture.

Additionally, it is recommended to ensure multiple Central Office trunk entrance points into the County to provide for redundancy in case of a major catastrophe. Concurrent with the re-design of the digital Microwave wide area backbone mesh network, diverse pathing for voice is available, and is recommended as part of the redundant design.

When the voice hubs are all at the same software level, implement a virtual voice network, with ISDN connectivity for full functionality of number identification, single system voice mail, and other benefits.

Conclusion:

Success of the enterprise network architecture development relies upon:

- Top down management support based on standard based solutions to business requirements.
- A county design strategy that follows the plan.
- A set of guidelines or standards to follow in implementing new technology.
- Buy-in from senior county management and all business clients.
- Development of standards based on OSF and Industry accepted solutions.
- Opt for a standard solution even when it is not the least cost solution.

In developing a migration to an Enterprise Network Architecture environment, the County must consider the following:

- The user community lacks a process to identify common requirements for open systems.
- The user community has no way to exert collective leverage on vendors to implement common requirements.
- Resources invested in systems and applications, and the attitude and culture of the work force, may make it difficult to evolve to an integrated Enterprise environment.
- Some business practices encourage a short-term approach to solving business problems, sometimes ignoring long-term integration issues.

Most of these are management issues, not technical problems. They must be addressed as the detailed network designs are developed and implemented.

Departments need distributed open systems to capitalize on new technology that supports department goals or opportunities, and to keep from being left behind.

PROJECT STATEMENT

Enterprise Network Architecture Project

Mission Statement:

The mission of the Information Services Department (ISD) is to assist and enable county department heads, elected officials, staff and outside agencies to accomplish their objectives by providing convenient, reliable and responsive information technology services and cost effective solutions to business problems.

Business Problem:

The Information Services Department provides Countywide support for voice, data, radio and microwave networks. The Information Services Department (ISD) employs approximately 110 personnel assigned to seven operational divisions: Business Systems (2), Planning and Technology Research, Administration, Production Services, Communications, and Customer Support.

In 1971, the County developed a comprehensive communications plan. This plan has been guiding County communications planning for the past twenty years. Concurrent with a change in key ISD personnel, the County opted to conduct a complete review of all telecommunications systems as a first step in defining a detailed strategy for supporting the County's growing communications infrastructure.

Recognizing the need to carefully plan for future systems, the County retained The Warner Group to assist in preparing a strategic plan for Telecommunications services. This plan was completed in March 1994 and approved by the board. This planning process incorporated information and underlying strategies contained in the Current Environment Document and the Information Management Strategic Plan compiled in 1992.

On July 18, 1994, the County contracted with Fleming & Associates, to develop a county-wide Telecommunications Infrastructure Strategic Plan. The County required a consulting firm with experience designing and implementing Distributed Computing Environments and Wide Area and Local Area Networks. They also required experience in integrating a variety of diverse topologies and protocols over private and public facilities, with a background supporting voice, radio, data, video, and imaging.

The County calls this project the Enterprise-wide Network Architecture Plan, and expects this plan to generate an Enterprise Network Design Model to guide the development and implementation of the county-wide Telecommunications Infrastructure.

The County utilizes a combination of complex mix of telecommunications facilities and systems to provide services to County departments and several cities within the area. The County's ISD manages the operation of separate voice, data, and radio systems on analog and digital microwave networks.

The development and implementation of these systems and their supporting networks were facilitated by ISD as part of a plan to provide a Countywide communications infrastructure. The ISD provides the maintenance and ongoing support for many of the existing systems and network components.

The current mixed network infrastructure and computing environment do not interoperate easily. Providing solutions to business needs require major expenditures and are very slow to develop. Over the last few years the value of ISD has been questioned by the various County departments.

Client groups feel that the costs of ISD services are no longer competitive, that the ISD technical department does not have the expertise to move the County into the next phase of technical development, and that the ISD department is not responsive to the needs of the business clients.

A study recently completed by Deloitte and Touche LLP for the County of San Mateo Grand Jury drafted September 16, 1994, is in agreement that ISD was not performing its mission effectively. The report determined 28 issues (findings) that need to be addressed by ISD before its mission can be accomplished.

Deloitte also developed over 30 recommendations and action plans ISD should implement to address the findings. Of those recommendations the Grand Jury identified the most significant recommendations as:

1. Appoint a Change Enabler;
2. Cultivate county-wide support;
3. Develop a county-wide Telecommunications Infrastructure.
4. Use a fixed fee approach for all ISD projects.

Business Solution:

This project by Fleming & Associates, focuses on significant recommendation number three (3) above to **Develop a county-wide Telecommunications Infrastructure**, and also includes the Deloitte recommendations to:

- "Develop Open System Standards"
- "Develop a Migration Plan" (Strategy)

Purpose:

The purpose of the **Enterprise-wide Network Architecture Plan** is to present the network architecture in developing a county-wide Telecommunications Infrastructure Model, using the following information:

- Review the Warner Group Strategic Study.
- Incorporate the feedback from the Deloitte and Touche LLP studies and Grand Jury recommendations.
- Reverse-Engineer the existing Network to define and develop specifications for a new network.
- Integrate the current projects with the planned architecture.
- Coordinate network design criteria for customer business needs with information produced by the Technology Architecture Specification project.
- Use Open Systems Standards generally based on the developing OSI reference model from the International Organization for Standardization (ISO).
- Use the Transmission Control Protocol/Internet Protocol (TCP/IP), as the design protocol for data networks throughout the County-wide network infrastructure.
- Use information regarding Asynchronous Transfer Mode (ATM) in developing the conceptual network design model, and as a guide for migrating toward future integration of voice, data, and video, on the Enterprise Network Architecture.

Scope:

The scope of this project is to document and describe the Telecommunications Infrastructure network backbone, the interconnecting mesh of communications paths, and primary backbone router locations. This network must also fully integrate with existing County Local Area Networks, and planned future networks.

This document will deal with:

1. The County-wide area network backbone.
2. The specifications for interconnection of individual LAN's to the backbone.

The project will develop the following deliverables:

1. An **Enterprise-wide Network Architecture Plan**, with a clearly defined, technologically advanced network Model, based on Open Systems standards, supporting an Enterprise-wide Computing Environment.
2. A **Migration Strategy** with a review of existing projects, projects in queue, future enhancements for systems development, recommendations for protocol migration to the new network, and guidelines on Open Systems integration.
3. **Open Systems and Industry-wide accepted standards** overview for the initial elements of the Network Infrastructure.
4. Recommend Network Design **staff training requirements**.
5. Provide **Job definitions for network design staff positions**.
6. Conduct **Preliminary training for specified ISD staff** members in enterprise network design.

7. Schedule initial **vendor interviews** and selections.
8. Provide **Design and Quality Assurance reviews** during the project.
9. Conduct a **Post project review meeting** at the end of the project.

This project will produce an Infrastructure design model based on industry-wide standards to be used to design solutions to business needs and changes. The model is designed to be used as a strategy for future development and implementations. As with any dynamic environment, the model will need to be updated as new industry standards and business solutions become available.

A mechanism to adjust the model (Enterprise Network Architecture) must be implemented by the county to continue providing responsive action in developing network and computing designs that support the changing business requirements of the customer.

Fleming & Associates will provide recommendations in the final phase of the project, that address dynamic changes in network modeling, to assist the county in developing a function within ISD to keep the Enterprise Network Architecture model up to date.

TECHNICAL REQUIREMENTS

Objectives

Voice and radio traffic predominate today's County-wide area network. The demand for a mix of Voice, Local Area Network data (including imaging), Client/Server applications, radio distribution, and in the future PC video is increasing. This will make the future County-wide Enterprise Network environment increasingly complex.

This project has identified two objectives in designing the conceptual network model:

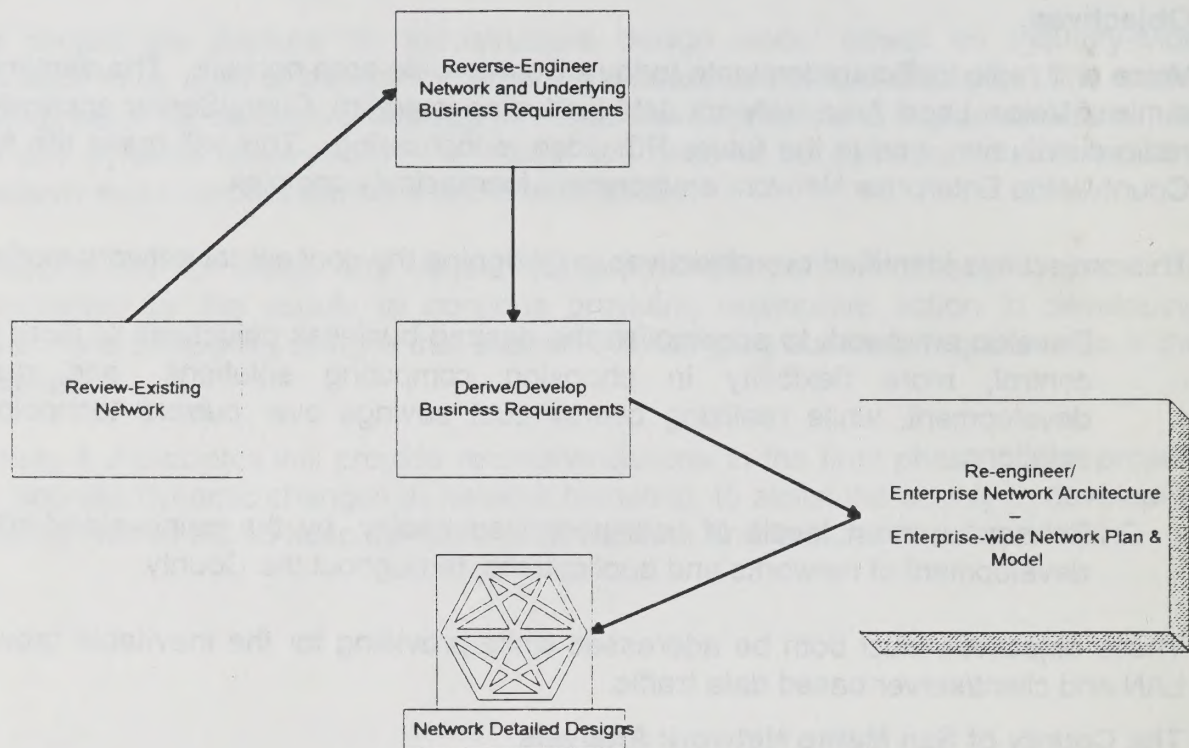
1. Develop a network to accomplish the desired business objectives of more local control, more flexibility in choosing computing solutions, and quicker development, while realizing overall cost savings over current technological solutions.
2. Enhance current levels of user-perceived quality, by the using standards for development of networks and applications, throughout the County.

These objectives must both be addressed while providing for the inevitable growth in LAN and client/server based data traffic.

The County of San Mateo Network Analysis

The County of San Mateo has a diverse mix of networks that needs to migrate to an integrated mixed heterogeneous network infrastructure. To integrate the these networks into an enterprise-wide network we need to first reverse-engineer the existing network by defining and developing specifications based on the current network, derive business requirements, then re-engineer a new network.

Example of Re-engineering process



As part of defining and developing specifications, the business requirements were verified using information from written surveys and focus group input from the Technology Architecture project.

Reverse engineering the County of San Mateo current network produced this view of the current network:

- A mix of hardware and software from different manufacturers.
- Separate work groups, many in different geographic locations, operating their own computing resources.
- These groups share little information and few resources.
- Because most of the systems are proprietary, it is hard to exchange information among them without major programming efforts.
- The staff usually solves the problem of exchanging information with tactical sneaker net.

Business Needs

Departmental needs throughout the County are changing, creating local requirements for the computing environment. Departments are moving off the dedicated Mainframe

terminals to intelligent PC based systems and connecting them together with small networks. Typically, these systems double as terminals for Mainframe application sessions, as well as, intelligent workstations supporting a variety of local software applications.

One example of this is the Financial Management System (FMS) that is based on a Unix client/server and IP network. Another example is a pilot program using client/server application for HSA including Imaging applications. The County ISD has also just completed a connection to the Internet and is evaluating Internet access into and out of the County network. These examples are just a few that indicate a move toward distributed and/or client/server computing environments using the industry accepted protocol for Enterprise Networks TCP/IP by County Departments.

Although this provides solutions to pressing business needs, without a strategic plan, it may prove difficult to inter-connect these systems together in the future. Without directions from County management, a set of standards on which to build, and a strategic plan, the county may have isolated network islands throughout the organization.

Using a standard network and computer development strategic plan designers can make sure technology choices reflect the needs of the entire organization. A strategic plan and established management guidelines help to control this process by using:

- Established guidelines for business users.
- Standards in requests for proposals.
- Ensuring that the final purchase decisions based on standards.

Management guidelines or standards, provide guidance to decision makers and must reflect the needs and views of all involved groups. This consensus process becomes increasingly important as organizations decentralize their decision-making processes in favor of local control. The guidelines for the County are well-supported industry-wide if the County adopts the Open Systems Standards discussed later in this document.

Serving the internal customer

The object of an enterprise network is to give County employees easier access to more information. Open system can play a major role in meeting that goal.

Technology can make an employee's work easier, not harder. With open systems, County employees can locally develop new business solutions on which they can capitalize without having to understand the technology.

In the past, the best-rewarded employee was often one who understood how to navigate the network, reach the mainframe, and use a complex report writer. The

employee who could do these things was better prepared to distribute information from corporate databases and valued above employees who did not have this experience.

Open systems help make information more readily available to all employees, so they can put it to productive use. All employees will learn how to retrieve information, and to link it with business reports or objectives, rewarding themselves and their organizations with increased value and productivity.

Productivity and control

The county business units enjoy some of the most tangible benefits from Enterprise Networks based on Open Systems. They will find these benefits in three general areas:

- Increased productivity and faster user response, with faster networks, greater computing power, and multi-tasking applications.
- Better control of the information technology environment, by sharing data, software, and hardware.
- Cost control, by managing growth and sizing at the local or department level in sizable chunks.

Indirectly, County departments will benefit from the Open systems improving programmers' productivity, because it makes their skills more portable. Common development environments, modeling, and management schemes give application developers and programmers a single set of skills the entire staff can gain and use. Staff members will not have to recreate existing applications from the bottom-up.

This frees them for other tasks such as developing new applications and responding to users' requests for changes. Developers can handle these much more swiftly, reducing the lag time that is a traditional source of complaints. This improved productivity is passed to the business user in faster applications development, with better quality.

Open systems bring a greater sense of control to business and MIS, from both technology and management perspectives. Because open environments are more predictable, County departments and IS managers will more readily be able to allocate resources and manage change.

Benefits to management

The best thing technology can do for a manager is to make itself invisible. Systems, software, training, and development expenditures within open systems come in manageable chunks. Making management planning more accurate, with investments implemented smoothly and in natural increments.

Open systems help create a flexible, transportable environment. As county business units change roles, or as new divisions develop, their applications, data, and systems can change with them. They can readily add or reduce resources to serve their new goals the county can enjoy three major advantages:

- Less emphasis on technology and more on business.
- Better ability to plan and manage technology investments in smaller chunks.
- Better response to local changing needs and objectives.

Business in the Future

Industry analysts are saying that business users want to share processing and data across heterogeneous environments. They want to be able to use resources available on different computers all around the company. Business users are looking at integrated voice, data, and video to the desktop. Business wants applications development at the local workstation, customized local reporting, and access to a variety of data throughout the enterprise. Often, local departments want to build there own computing environment to serve the local needs.

On a larger scale, the desktop computing revolution has replaced one form of centralized computing with another. Instead of central control at the mainframe, we are dispersing control to the departmental and LAN levels. This environment becomes more difficult to manage.

This is why guidelines or standards are needed to support the department or LAN managers in selecting hardware, software, or developing applications. Additionally, the network is now part of the computing environment and requires more complex network management tools. A centralized network management tool is needed with appropriate hardware and software to efficiently diagnose and correct network problems.

Even with the issue of standardized hardware, software, development and network management, department users don't want to revert to the mainframe days, when data was so carefully managed it difficult or impossible to modify or change at the local level. They want a system that uses information to truly empower their employees.

Industry Guidelines - Open Systems

The County of San Mateo information systems network has been designed around IBM's System Network Architecture (SNA), a proprietary, non-routable, connection-oriented, centrally controlled and well-established data communications architecture. For some years, the computer industry has been moving away from this approach toward one that is non-proprietary, routable, flexible, and decentralized.

The County of San Mateo information network has been designed around IBM's System Network Architecture (SNA), a proprietary, non-routable, connection-oriented, centrally controlled and well-established data communications architecture. For some

years the computer industry has been moving away from this approach toward one that is non-proprietary, routable, flexible, and decentralized.

The County has recognized this trend and is attempting to move in the direction of open systems. Open systems has many meanings and many standards organizations, including government agencies, industry associations and vendor consortiums.

The following is a brief overview of the more significant standards organizations:

1. International Organization for Standardization (ISO), an agency of the United Nations, developed the Open Systems Interconnect Model (OSI). The OSI model stipulates seven layers of data communications categories and is the basis by which all Open and proprietary data communications architectures are compared.
2. The Institute of Electrical and Electronics Engineers (IEEE), and industry association, has established the following Open Systems standards:
 - IEEE 802.3 protocol at the Data Link Layer of the OSI Model - The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is the standard for Ethernet networks.
 - IEEE 802.5 protocol at the Data Link Layer of the OSI Model - The standard for IBM's Token Ring networks. The International Standards Organization has now adopted these standards under ISO8802-2 for IEEE 802.2 and ISO8802-5 for IEEE 802.5.
 - POSIX (Portable Operating Systems Interface for Computer Environments) - Defines a command set and other characteristics of standard operating systems. POSIX is based upon, but not restricted to, UNIX operating systems. POSIX was adopted by the national Institute of Standards and Technology (NIST, formerly the National Bureau of Standards) in 1992 as a Federal Government computer standard.
3. Open Software foundation (OSF), a vendor consortium, comprised of IBM, HP, DEC, SUN, and others, which has established the following Open Systems standards:
 - Distributed Computing Environment (DCE)
 - Distributed Management Environment (DME)
 - Motif, a UNIX-based graphical User Interface
4. X/OPEN, a vendor consortium, comprised of IBM, HP, DEC, SUN, AT&T, and others, which has established an Open Systems certification program, by which products considered open are certified. This certification standard is XPG-4, X/OPEN Portability Guide 4, which attempts to certify the ability of products from various vendors to port software without regard for hardware manufacturer.

Data communications standards from OSI combined with platform standards from XPG-4 ensure a fully functional open systems environment. In prioritizing standards, industry recognized de facto standards take precedence over legislated standards. An example of this is the Simple Network Management Protocol (SNMP), a de facto standard for network management takes has displaced the developing DME standard. Eventually, the DME standard may take a leading role in the industry as the standard becomes fully developed. This is a common process when dealing with standards due to the lengthy process of developing standards from the various standards committees.

The County of San Mateo is fully involved with communications standards with the current implementation of Ethernet and Token Ring networks. And with the recent installation of a TCP/IP network for FMS. This moves the County toward a solid strategy of open systems standards consistent with the communications industry and product development.

Keeping Network standards closely coordinated with platform standards ensures a high degree of compatibility, inter-operability, and integration.

Standardization that creates open systems take place at each of three levels:

- *Products and technology based on established standards.* PCs are an example here, most are Intel based and Windows operating systems. New operating systems are available for Intel based systems that provide the interoperability of Unix by supporting native level TCP/IP.
- *Standard development of applications.* Standardization here allows for porting applications across various platforms, modeling software to build upon previous work, and use of CASE tools to speed up development.
- *Middleware.* This is the layer of software that often lies between an application and the operating system or platform. Middleware is not part of either the application or the platform. Examples include databases, graphical interfaces, electronic mail, management tools, and application development tools.

Product and Technology Standards:

Standards are probably the most familiar component of open systems. They form the basis of such useful working features as portability and interoperability. They do not by themselves establish open systems.

The County of San Mateo Enterprise Network Architecture is a conceptual (strategic) network design. The initial network specifications are based on work done by the Open Software Foundation (OSF), International Organization for Standardization (ISO), and Industry-wide accepted Open System Standards.

The design used for planning the County-wide Telecommunications Infrastructure used open standards to develop a network that conform to open inter-connectivity and inter-operability standards.

Standard Development:

A true open system uses a building process. Newly developed technology can take advantage of existing technology, such as:

- Design the new elements so they take advantage of existing components.
- Design the new elements so future developments can take advantage of them.

Standards help assure maintenance of this process, and that the county can continue to build on previous work.

Application development in an open system uses state-of-the-art software development tools. Some tools can be used at local department to develop custom applications. This supports the need for local development and flexibility. This also requires standards to guide the departments to ensure portability of applications throughout the enterprise.

Middleware:

With the recent emphasis on open, standards-based technology, middleware is drawing more attention. It is becoming more independent of specific platforms. It uses standard protocols and interfaces when they are available and mature.

Standard middleware is the model adopted by users who decide to standardize on a particular component or set of components. Standardization at the middleware level represents a flexible open systems interface model. It offers more choice and, if implemented in a disciplined way, does the best job of avoiding proprietary products.

To guard against being locked into a particular form of middleware, many businesses and standard setting organizations have adopted a process called *profiling*. A profile is a suite of standards. These standards specify the functions you need to meet the requirements for a given purpose.

Profiles can pay off in many ways. They give the County a way to capitalize on the use of standards within an organization and on a much broader scale than would otherwise be possible. In a business setting, profiling often takes the form of corporate guidelines, standards, or specifications. The County can often use these in the standards requirements sections of RFPs.

A profile can specify either a complete open systems environment (OSE) or an application-specific environment specified through Application Environment Profiles (AEP).

An AEP identifies the needs of the application area, cites the standards available that meet those needs, and notes any gaps that may exist between the needs and the standards. There may be non-standardized technology available to fill these gaps. Examples of applications that could have their own profiles include Computer Aided Design (CAD), PC software and EMail.

Varying department working conditions and user needs can often produce differences among various organizations' profiles.

Distributed Computing Environment:

Open systems also promise to support distributed applications that will significantly enhance productivity throughout the organization.

Open systems can improve productivity compared to competing systems, they are more powerful, more responsive, or both.

Additional productivity is likely because:

- DCE offer the benefits of multitasking.
- Faster desktop systems. They demand more from the servers that support them; OSI or Transmission Control Protocol/Internet Protocol (TCP/IP) based servers help meet that demand.
- Growth in manageable modules. Keeps staff up to date with leading edge hardware and software that can be customized and flexible to support local objectives.

The reason for recommending open systems for the County of San Mateo Enterprise Network is the ability to implement distributed computing through the Enterprise Network Architecture. Distributed computing is at the heart of enterprise networking and client/server computing.

In the past, distributed systems have been proprietary. Each major computer manufacturer designed its hardware and software to provide interoperability among that company's systems, e.g. DEC and IBM. If you stayed within your chosen vendor's system, things could hardly be more uniform.

Modern desktop-centered distributed computing while uniformity of hardware and software is not the case, industry accepted standards provide for inter-operability and inter-connectivity. One of those choices comes from the **Open Software Foundation (OSF)**, the other from **accepted de facto industry standards**. Both aim to provide distributed platforms that span multiple architecture's, protocols, and operating systems.

OSF's product is the **Distributed Computing Environment (DCE)**. Where DCE standards leave off de facto industry standards take over, driven by users like the County of San Mateo who demand inter-operability and inter-connectivity functionality from vendors.

DCE is destined to become recognized standards for distributed computing. **DCE standards respond to the needs of customers who are creating distributed environments on their own.**

OSF was best known for their version of Unix, but today's distributed environment does not depend on any particular operating system. DCE works as well on Mac's or PC's as it does on Unix. OSF is an open-systems organization which is only part of the broader open-systems philosophy. Like distributed computing, this philosophy is based on inter-operability, scalability, portability, and compatibility among different architectures.

The County of San Mateo Enterprise Network Architecture design is based upon distributed computing and the emerging standards supporting the DCE model by OSF. Unix is already a part of the County network. Continuing to build an Enterprise Network upon Unix based systems will be more expensive, and more complex than Intel based systems.

Building a network based on DCE with Intel based servers and workstations will give the county more flexibility in inter-operation, scalability, and portability. The Intel systems generally cost less than Unix based systems, and can be better supported by the existing skill sets of the staff. This concept allows for leveraging off the existing knowledge and technology within the County.

On the basis of recent OSF standards for distributed computing environments, a high return on investment is possible with this technology. It is a distributed system that offer solid support to expansion-minded business objectives. Distributed Computing allows the end-user to build in smaller chunks, necessary to fulfill their local objectives.

The Open Software Foundation's Distributed Computing Environment (DCE) is designed as a comprehensive enterprise-wide networking scheme. It's gained attention from many vendors, including some non-OSF members. Unix Systems Laboratories (USL), owner of Unix System V and co-developer with Novell of Unixware, says it will integrate DCE into its future products.

Benefits of DCE:

One big advantage of DCE is a true distributed file system. This system is based on the Andrew File System (AFS) developed at Carnegie-Mellon University. AFS provides a common environment for any workstation on the network.

DCE also is strong in Remote Procedure Calls (RPCs). The DCE RPC lets a program on one system call a subroutine on another, even if the second system has a different

processor and operating system. If the target system is different, it can translate the information to its own format.

Network security is also a major DCE feature. It lets the target system authenticate each procedure call setup. This keeps hostile users -- or just ham-handed ones -- from writing programs that might cross a network, make unauthorized access, or damage files. The authentication can have multiple levels with associated privileges. For example, an individual may be allowed to read data, but not to change it.

A Distributed Computing Environment (DCE), which ties applications together across the distributed network and SNMP (de facto standard for DME), which captures network fault information to display in a central network management center, provide scalable, interoperable, and flexible systems that support quick economical solutions to business objectives.

DCE's services fall into two categories:

- Fundamental distributed services.
- Data sharing services.

Fundamental distributed services:

This group includes tools with which software developers can build user services and applications. These services include:

1. *Remote procedure calls.* An RPC lets you build applications that use individual procedures running on computers across a heterogeneous network. It includes two components that help in building Client/Server applications:
 - An RPC facility that provides simplicity, performance, portability, and network independence.
 - A compiler that converts client and server interface descriptions into C source code. This lets RPCs behave in the same way as local procedure calls.
2. *Directory Service.* The directory service provides a single naming model for resources such as servers, files, and disks across the distributed environment.
3. *Time service.* DCE maintains a distributed time reference to synchronize activity and events among the computers on a network.
4. *Threads service.* Threads control program flow. They let an application process many commands simultaneously. Programmers can use this feature within local or distributed environments. Thread service is also useful in client/server control, because a server can initiate many threads to clients.

5. *Security service.* This service authorizes, authenticates, and manages user access to individual hosts on the distributed network. It includes a secure RPC to protect the integrity of communications, Kerberos authentication to validate the identity of a user or service, authorization tools that control user access to resources, and a user registry to manage user account information.

Data sharing:

The data sharing services are based on the Fundamental distributed Services standard. These provide extra functions without the need for extra programming.

In DCE, these services include:

- *A distributed file system.* DFS is the key information-sharing component. It joins the files and directories of individual workstations and provides a consistent application interface.
- *Diskless support.* The distributed file system supports diskless workstations and provides protocols for diskless support.
- *Personal Computer Integration.* PCI lets Unix, MS-DOS, and OS/2 users share files, peripherals, and applications.

Client/Server:

A distributed computing environment includes two or more client/server combinations in a potentially huge network. With more than one server, you can split, modularize, and spread the applications, services, and data across the servers. Servers can then pass information among themselves; a server thus can be a client to another server.

A distributed environment consists of several important elements:

- This is the backbone of distributed computing. DCE supports OSI networking protocols, TCP/IP, and X.25, as well as many others.
- *Remote procedure calls (RPCs).* RPCs manage communication among applications distributed across heterogeneous networks. Distributed systems also need name or directory services. These manage and control location changes of resources, applications, and even users. They also need time services to synchronize the activities of the various computer in the distributed environment.
- *Distributed file system.* This component provides global file access. Examples include Sun's Network File System (NFS) and OSF's DFS.
- *Security.* As with any kind of network, you need authentication and authorization mechanisms to deter unauthorized users.

- *Transparency.* Human clients can use all these features without having to worry about them, or even to know that they exist.

Existing LAN Integration:

Distributed Computing and Client/Server also have important foundations in local area networks. LAN technology includes several methods including RPCs, transport protocols, and network authorization systems to help provide interoperability at the local network level.

These developments alone are not enough to support an enterprise network. In combination, they also are often insufficient. What's more, they don't work readily together. The challenge is to try to figure out which platforms, protocols, naming services, authorization systems, and other features work with which other elements of the network. Expanding the scope from a LAN to an enterprise network multiplies the complications.

The County will not soon be rid of the varied LANs and other disparate systems that probably have sprung up around the County. As a practical matter, the Enterprise Network Architecture plan will be integrating them into the system, not replacing them. The Enterprise Network Architecture design plan will allow inter-connection of various department LAN's together via a high speed non-proprietary, distributed, routed, highbred mesh topology network.

Projects such as the Enterprise Network Architecture are a form of downsizing. Downsizing is a transition from mainframes to PC local area networks. This kind of downsizing requires that diverse systems work together smoothly.

Today, as a downsizing option, Intel based networks have become more useful with more powerful servers, native TCP/IP, Intel based networking software, and graphical user interfaces.

The conceptual design for the Enterprise Network Architecture plan expects to include the following elements:

- A client/server platforms based on open operating systems with TCP/IP protocol.
- Router/Hub/Cell Switching, that inter-connect local area networks using TCP/IP, or providing translations for IPX, SNA, or other protocols on non-TCP/IP networks.
- A platform that manages the distributed enterprise network, based on the latest available end-to-end SNMP compatible Enterprise Network Management Software.

Distributed open systems are a step beyond client/server computing. In a basic client/server system, one server meets the needs of several client. In a distributed

environment, there are several servers, perhaps one in each department. Each serves a group of clients within its group. Each also is available to members of other workgroups.

Distributed environments provide the platforms for distributed applications. The first distributed applications have generally been simple ones like e-mail and distributed file systems. The most common early use of distributed systems was to share resources like database information and printer services. As the technology evolves, distributed computing software developers can provide more sophisticated applications written to capitalize on the distributed environment.

Migration Strategy for Protocol Integration:

The county is not ready to make the financial and organizational commitment of converting wholesale to an Open System based client/server system. The cost is prohibitive, and the payoff is uncertain. A wholesale conversion could actually reduce productivity.

The practical scenario for the county is that open systems will increasingly coexist within the county's enterprise network, sharing the assets with PC's and larger systems. The mix will include Intel *Ox86-based systems running MS DOS (with or without Windows), Windows NT, Windows 95, OS/2; RISC systems from Sun, HP, IBM, Digital, and others running varieties of Unix; and various proprietary computers with operating systems like MVS and VM.

SNA Strategy:

IBM's Systems Network Architecture (SNA) with Synchronous Data Link Control (SDLC) protocol traffic will not likely disappear in the near term, and most likely will play a long term role in the County for some mission critical data/applications. It is estimated that more than 90 percent of today's industry-wide mission critical data is carried on SNA networks.

San Mateo County has taken the initial steps toward implementation of open and distributed systems based on TCP/IP, and inter-connections of non-TCP/IP LAN systems. Yet, SDLC, and mainframe sessions will continue to require unique handling as long as the mainframe is required.

TCP/IP is the preferred protocol for network migration. Integration of SDLC into this protocol is recommended as the most efficient way of transporting SNA traffic. SNA over IP supports non-disruptive high-performance route switching of integrated SNA in the Enterprise Network Architecture strategy for the County..

In the interim, as the County increases the TCP/IP environment throughout the County it will be necessary to begin integration of SNA traffic into the TCP/IP traffic flow. This will simplify the network, provide for routable SNA traffic over the same channels used by the TCP/IP traffic, thus reducing bandwidth usage. This also continues the County migration to open systems technology throughout the network. This process of encapsulation of SNA-SDLC traffic in IP data packets through routers is called SNA-SDLC tunneling.

IBM will introduce Advanced Peer-to-Peer Networking Plus (APPN+) sometime late 1995. This protocol is specifically designed for SNA traffic over Router-based networks. The APPN+ protocol will be more efficient in handling SNA traffic over Routed Networks than SNA over IP according to IBM literature.

This option is mentioned here to advise the County design staff that a review of the SNA issue would be appropriate at the time APPN+ is available to determine if this protocol is appropriate for the County. If APPN+ is appropriate the impact of APPN+ and TCP/IP protocols co-existing in the Enterprise-wide Network Architecture without creating too much complexity.

Novell and IPX

The County of San Mateo network environment is currently made up of mostly Local Area Networks running Novell software with IPX protocol. This environment is likely to continue for now and perhaps the future. This type of LAN is the most prominent type system that is currently in use by the County.

The ISD network design staff is continuing to use the Novell environment in planning future network scenarios. Novell has a large installed base throughout the industry, and although some companies are opting for other network solutions, Novell is still the predominant network software in the communications industry.

Due to the loss of market share recently to Windows NTS with native TCP/IP, Novell has opted to include native TCP/IP in future releases starting in early 1995. This should help Novell continue to compete in the network software market for LAN software capable of directly interfacing with IP Wide Area Networks, and Enterprise Networks running IP protocols.

This Enterprise Network Architecture plan encourages continued development of Local Area Networks using Novell software, and when available, using native TCP/IP interconnection to the Enterprise Network.

UNIX and TCP/IP

An effective heterogeneous networking strategy has these main elements:

- It adapts to multiple Local Area Network architectures into a single, standardized solution.
- It is a well-supported standard that scales well and is manageable. **Today, that is TCP/IP**; and in the future, ATM cell-switched technology may be a practical alternative.
- It offers a suite of standard services, such as file sharing, network printing, and remote access.

Because some LANs require traditional PC network protocol support within individual LANs such as Novell's IPX, it will be necessary to support these protocols on LAN servers. This can be accomplished adding TCP/IP to each client PC to provide a common standard of service or by converting the IPX protocol at the interface with the Enterprise Network. Native TCP/IP is already the standard in all Unix systems and some newer Intel based network software, so no conversion is necessary.

The industry accepted protocol choice based on the predominant networking services in use today is TCP/IP based networking. The best way the County of San Mateo can migrate to this Enterprise Networking protocol is by upgrading the current LAN network systems to native TCP/IP based systems.

Other options to migrate to TCP/IP inter-connectivity are:

- Connecting non-TCP/IP networks into a TCP/IP servers,
- Connecting to an existing Unix network server, or
- Encapsulating non-TCP/IP protocols into IP at the inter-connect point of the Enterprise Network.

TCP/IP systems usually be use Network File System (NFS) and related protocols. PCs can use DOS versions of the same networking service, such as that provided by Sun Microsystems' PC-NFS, or Windows NTS. This initial decision will affect which lower-level architecture you use. By migrating to TCP/IP on all systems, NFS becomes the obvious choice for file sharing, because it uses a widely available, scalable network architecture.

Viewing the network from the workstation, a modern network provides connectivity outward to all users and information sources. EMail, scheduling, data sharing, remote hardware access, is available to all users. EMail and scheduling included with software choices should conform to Simple Mail Transfer Protocol (SMTP), with Multipurpose Internet Mail Extensions (MIME).

IP Networking

Today, voice, radio, TCP/IP and non-TCP/IP data are supported individually with separate channels on the County-wide Microwave network. TCP/IP based networking is today's industry-wide accepted protocol to provide inter-operability and inter-connectivity for data networks. The County of San Mateo has adopted this protocol for connectivity to the Internet and networking the FMS project.

Continued migration to TCP/IP protocol is recommended and provides an **interim** solution for the future Enterprise-wide Network to transmigrate the existing network in the County from a complex network of individually assigned network channels, to a

network based on an integrated TCP/IP protocol channel for all data, with separate channels for Voice and Radio, on the Microwave network as the interim solution.

Integration of non-TCP/IP data into TCP/IP packets allows the staff to design simplified network paths to interconnect all the departments throughout the County with less demand on bandwidth. Connecting network elements together in a less complex network path provides for EMail, data exchange/sharing, remote printing, cross network file/hardware access, and simplified end-to-end network management for all data.

This plan assumes the digital Microwave network is the primary Wide Area Network Backbone and is the best strategic facility to build upon for the County. This assumption is based on the on-going need to support two way radio distribution to transmission sites, ownership of the existing Microwave systems, need to control the entire network in emergency situations, and the initial cost to replace such a network.

By leveraging the existing Infrastructure into the future Enterprise Architecture the County of San Mateo continues to build upon known technology, reduces cost of new network paths, required training, and acquisition of experienced staff.

The analog Microwave network will require upgrades to the digital radio systems as outlined in the Warner Group County-wide Telecommunications Strategic Plan. Additional paths via public network systems, such as Frame-Relay, ISDN, or other links will augment the Microwave network. In providing digital paths for data, we also provide additional paths for voice, radio, and in the future video.

Introduction to ATM

As demands for voice, data/imaging, and radio increase, the need for more bandwidth will inevitably increase as well. This demand may eventually drive the need for bandwidth beyond what is economical or feasible for the Microwave network.

Demands placed on the network will force the design staff to look for ways to reduce bandwidth usage. Cell-Switching technology, based on Asynchronous Transfer Mode (ATM) standards, promises to allow a variety of network applications to efficiently share expensive bandwidth resources.

The ultimate future solution for the County of San Mateo Enterprise-wide Network Architecture is an interoperable, portable, protocol that integrates voice, data/imaging, radio, and perhaps video into the available bandwidth efficiently.

Along with voice transmission on cell-based transport, this unique transport is capable of providing optimal non-voice applications by using bandwidth space between voice cells. ATM provides efficient transport of voice, data, and future video, maximizing the bandwidth usage.

As users develop applications using imaging and/or other high volume data traffic, the future County of San Mateo Information Services department is likely to encounter

mounting pressure to provide increasing levels of connectivity requiring more bandwidth for departments throughout the County.

At the same time, the IS department must consider network consolidation and integration strategies to control and reduce overall networking costs.

ATM is a set of developing standards and technologies for switching information in fixed-length cells over high-speed lines. ATM supports integrated data/imaging, voice, and video in a broad range of environments, including desktops, wiring closets, enterprise switches, and carrier central offices.

ATM's appeal is its capability to operate over local area networks, wide area networks at speeds from T1, to tens of megabits per second, or gigabits per second. Today, ATM is emerging as a cost effective technology and standard that is being implemented in a variety of business applications.

ATM may be understood as any or all of the following:

1. A new LAN technology intended to replace Ethernet and Token ring technologies.
2. A universal Layer 2 (data link) protocol for extending LAN applications over metropolitan area networks and wide area networks.
3. A switching technology that allows efficient support of multimedia services.
4. A multiplexing transmission mechanism that provides, at the expense of some channel efficiency, seamless access to bandwidth on demand.

The County of San Mateo Enterprise Network Architecture plan recommends items 2 through 4 above in the future for solving wide area network bandwidth capacity issues, or for providing greater levels of information integration throughout the network.

Voice Systems

The Northern Telecom SL-1 and Meridian-1 telephone switches installed throughout the County generally function efficiently with few operational problems. Identified needs and requirements relating to voice communications are focused in the areas of standards and technology migration. The current voice network provides a robust, reliable voice communications system throughout the County. The following design criterion considers several factors such as current product performance and flexibility, the ability of the systems to integrate with other existing systems, ability to expand, and migration path.

The current system has the following capabilities:

1. Seven SL-1 and one Meridian-1 interconnected via land lines and digital microwave paths. Primary Hub at Redwood City facility.

-
- On net capability with delivery to off net closest to destination.
 - Direct trunks at each SL-1 location for standalone operation in an emergency.
 - Redwood City and County General Hospital have 12 hour battery and Generator UPS.
 - All other locations have two to four hour's battery UPS.
2. Voice systems supported by five voice mail systems and one integrated voice response system.
- Octel Aspen voice mail with current capacity for 400 users and maximum to 3000 users interfaced with Redwood City and one at the Harbor SL-1's.
 - Octel Branch voice mail system with maximum expansion capacity of 500 users interfaced with the Huntington switch.
 - San Mateo County General Hospital SL-1 interfaced with Digital Sound Voice Server for voice mail and automated attendant capabilities. This product can support up to 20,000 users.
 - A Meridian Mail Voice system is interfaced with the Redwood City Switch.
 - An integrated voice response technology is used by the Municipal Court for traffic related functions. The system called SIMPACT is interfaced to the Redwood City Switch and County mainframe via a SUN server connected to the ISD Token Ring backbone.

Upon reviewing the needs of the County for future voice requirements this document design recommends the following strategy.

Continue upgrading the current SL-1's with Meridian-1 level architecture. Additionally, this design recommends multiple trunk entrance points in the County to provide for redundancy in case of a major catastrophe.

DESIGN CONCEPTS

The Enterprise Network Architecture design plan lays out a strategic engineered structure of elements on which to build consistent integratable network designs.

An effective structured engineering network strategy is one that:

- Adapts multiple network architectures into a single standardized solution.
- Supports open or industry-wide standards that scales well and are manageable.
- Offers standardized services, such as file sharing, network printing, and remote data access.

The county will base the technical design specifications on the business requirements using Open System Standards and accepted industry-wide standards that assist in making design assumptions for this network.

The San Mateo County Enterprise Network Architecture design is based upon:

- The current network environment defined by reverse-engineering.
- Open industry-wide standards developed by the International Organization for Standards (ISO).
- Standards for networking in an open systems environment that are described in a reference model Open Systems Interconnection (OSI).

Using open or industry-wide standards in developing county network designs ensures hardware/software selections used in the network are more likely be compatible as technology changes. This enhances the possibility of getting more out of the design and investment in the new network.

The Enterprise Network Architecture provides an engineered structural design, based on widely supported standards. County network designers use this architecture in developing consistent network implementation designs that integrate legacy systems with new Enterprise systems.

Migration:

TCP/IP Workstation View:

This section views the network from the workstation in a modern network that provides connectivity outward to all users and information sources. EMail and Scheduling should be available to all users.

TCP/IP protocol is recognized as the de facto standard for 'Backbone' Inter-network connectivity. Non-TCP/IP protocols such as Novell IPX will need to be bridged and/or migrated to TCP/IP network Servers. PC Workstations will be upgraded to network compatible graphical user interfaces, such as Windows for WorkGroups v3.11.

The PC Workstation networks will work most efficiently using a form of native TCP/IP access, such as the Microsoft 32 bit Winsock. EMail and Scheduling included with network software should conform to Simple Mail Transfer Protocol (SMTP), with Multipurpose Internet Mail Extensions (MIME).

Current Products Available:

The migration to a TCP/IP is flexible in the sense that it can be done in a number of different ways, in the past it was by implementing Unix based workstations and servers. Today, powerful Intel based workstations and servers work with new operating system software with native TCP/IP capability.

Unix based systems are a costly migration solution for TCP/IP inter-operability and connectivity because UNIX based workstations and servers are more expensive than Intel based systems.

Using Intel-based systems to build upon, the County of San Mateo leverages their resources in integrating existing non-TCP/IP networks into a heterogeneous TCP/IP network.

Two solutions are Microsoft Windows NT and NTS, and Novell 4.x, with native TCP/IP, due out later this year. These two products support open systems OSI standards, provide native TCP/IP to the desktop, and provide a wide range of protocol conversion for non-TCP/IP networks.

Novell is a standard operating system within the County of San Mateo. The Enterprise Network Architecture plan supports both LAN environments. The Novell environment is well known in the County. Windows NT and NTS are relatively new.

Below is a brief description of some characteristics of Windows NT and NTS:

- MSMail included with software.
- Remote Access Service (RAS) included with NT and WFW. POTS, X.25, PBX and ISDN drivers included.
- Dynamic Host Configuration Protocol (DHCP) included with NT, NTS and WFW (Winsock32).
- Scalable server platform.
- NT is multitasking and multiprocessing.
- Client/Server platform-NT and WFW are ready for client/server plug and play applications like SQL Server or Oracle Workgroup Server.
- TCP/IP connectivity to the desktop.

PC's that are currently operating under Novell Open Data-Link Interface (ODI) and Windows 3.1 can be upgraded to allow the PC to connect to NT Advanced Servers, Novell Servers, non-TCP/IP Hosts, and IP Hosts.

By installing Microsoft's Network Driver Interface Specification (NDIS), and Windows For WorkGroups in conjunction with Novell (ODI) and Winsock32 (TCP/IP) an environment is created providing protocol-independent Network Interface Cards (NIC) in the PC.

Novell Servers that cannot be migrated to NTS initially can be bridged using NTS's built-in Netware Support. This allows the NTS to mount the Novell Server's volumes and then share them on the network.

Novell has announced plans to upgrade their software in mid-1995 to provide for native TCP/IP, and it is most likely that other LAN software vendors will follow suit. IBM has announced native TCP/IP and routing in their new 3746 FEP.

Other Benefits for Intel based Workstations and Servers:

- Reduced cost on future Intel based servers and PC's for the desktop.
- Increased performance and security.
- Reduced administration.
- Less staff training required.

IP Addressing:

During the Internet implementation project, the County received a Class C Internet IP address from the Internet community. Unfortunately, the Class C set of IP addresses are for small Network environments. This means that the County does not have sufficient IP addresses to assign a unique address to each IP workstation in the County.

To solve this problem, software is being evaluating that allows the IP addresses to be assigned through a proxy name server that assigns a fictitious IP address to the workstation. This proxy server will also map the fictitious IP address to a real IP address when communicating with the Internet.

Below is a description of one type of proxy IP name server software called Dynamic Host Configuration Protocol, that is part of the Windows NT family of network software.

The overview provides an example of the process used to operate this type of IP addressing solution. This is not necessarily the solution selected by the County. The County is planning to evaluated several software solutions for this process.

The information provided here is for discussion only, the solution selected by the County may not have the same hardware or software, however, the process will approximate the discussion below:

Dynamic Host Configuration Protocol Overview:

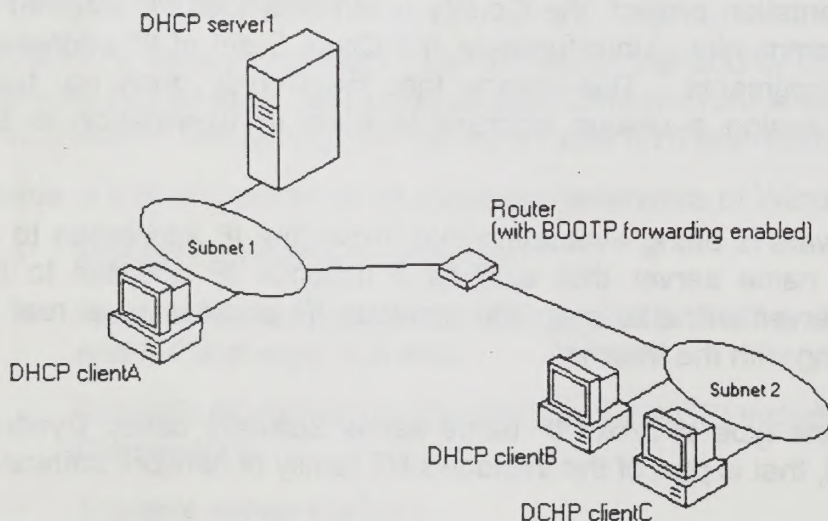
Assigning and maintaining IP address information can be an administrative burden for network administrators responsible for inter-network connections. Contributing to this burden is the problem that many users do not have the knowledge necessary to configure their own computers for internetworking and must therefore rely on their administrators.

The Dynamic Host Configuration Protocol (DHCP) was established to relieve this administrative burden. DHCP provides safe, reliable, and simple TCP/IP network configuration, ensures that address conflicts do not occur, and helps conserve the use of IP addresses through centralized management of address allocation. DHCP offers dynamic configuration of IP addresses for computers, plus the ability to associate duration leases with assigned addresses. DHCP also provides for inter-network configuration of certain diskless workstations.

As an example of how maintenance tasks are made easy with DHCP, the IP address is released automatically for a DHCP client computer that is removed from a subnet. A new address for the new subnet is automatically assigned when that computer reconnects on another subnet. Neither the user nor the network administrator needs to intervene to supply new configuration information.

The following illustration shows an example of a DHCP server providing configuration information on two subnets. If, for example, ClientC is moved to Subnet 1, the DHCP server will automatically supply new TCP/IP configuration information the next time that ClientC is started.

DHCP Clients and Servers on a Routed Network:

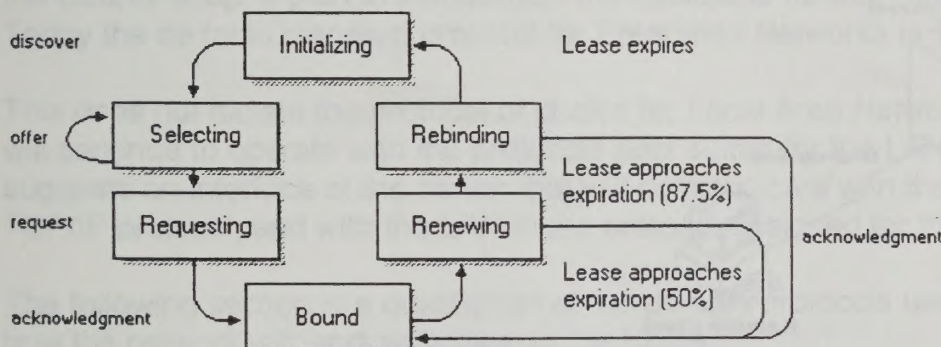


DHCP uses a client-server model. During system startup (the initializing state), a DHCP client computer sends a discover message that is broadcast to the local network and may be relayed to all DHCP servers on the private inter-network. Each DHCP server that receives the discover message responds with an offer message containing an IP address and valid configuration information for the client that sent the request.

The DHCP client collects the configuration offerings from the servers and enters a selecting state. At this time, one or more DHCP servers on the inter-network can have outstanding offers for this client. Each DHCP server reserves the address it offers, so that the same address cannot be offered to another client. When the client enters the requesting state, it chooses one of the configurations and sends a request message that identifies the DHCP server for the selected configuration. Each of the DHCP servers that received the original discover message also receives the request message. Any servers that had outstanding offers for this client then return the offered addresses to their free address pools.

The selected DHCP server sends a DHCP acknowledgment message that contains the address first sent during the discovery stage, plus a valid lease for the address and the TCP/IP network configuration parameters for the client. After the client receives the acknowledgment, it enters a bound state and can now participate on the TCP/IP network and complete its system startup. Client computers that have local storage save the received address for use during subsequent system startup.

DHCP Client State Transition During System Startup:



For more information about DHCP relaying, see the documentation for specific router.

Remote Access Service:

The County is moving toward a distributed network, and as such needs to provide for remote access to the wide-area network and the Local Area Networks. This access must allow for efficient access to the network and its data files. It also should support Tele-commuting issues.

The specific plan for remote access is part of the County of San Mateo Technology Architecture project. The County is evaluating several remote access solutions and may not select the one described below. However, the process described below should approximate the solution selected by the County.

This information provides a brief description of one type of remote access and its capabilities to provide access to the network and data information.

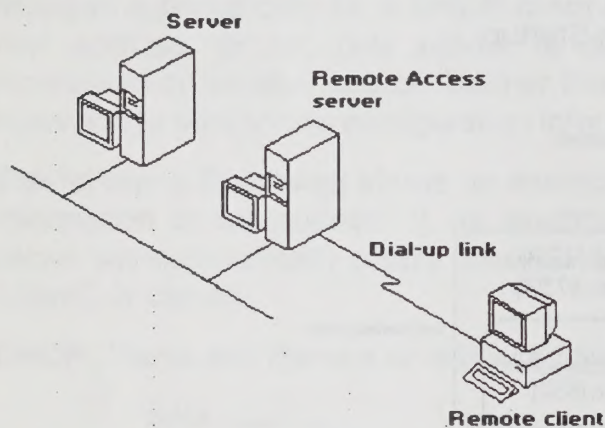
RAS Overview:

Microsoft Remote Access Service (RAS) for Windows for WorkGroups lets users connect to the office network from a remote site. This could be from home, a hotel, or anywhere there is an outlet for your portable or laptop computer and phone jack for your modem. Once you have connected, Remote Access lets you work with all your applications as though you were physically in the office, directly connected to the network or local database. This solution also addresses issues related to remote access in case of Disaster Recovery scenarios.

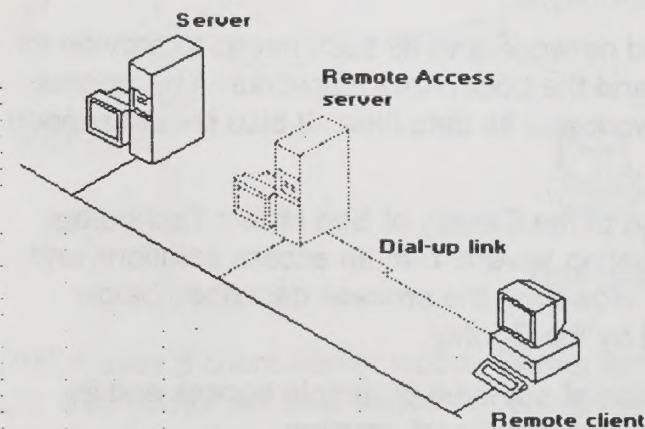
For example, users can access remote databases through the Windows for WorkGroups File Manager to:

- Send and receive electronic mail.
- Print files on the office printer.

From the client workstation, you can call the Remote Access server and connect to the network through the phone line, as shown in the following illustration:



After connecting, the telephone link is transparent. That is, you can access and view network resources in the same way as your office colleagues who are working on computers physically connected to the LAN.



Protocol Migration:

The County of San Mateo has a mix of protocols throughout the County network. This creates a difficult environment upon which to develop network solutions, develop long range plans, or to manage and maintain. Providing network paths/channels for this type of mix is also costly in terms of purchased bandwidth, or for equipment to support the requirements for wide bandwidths.

Integrating various protocols into a single protocol data stream is effective in reducing the need for large amounts of bandwidth and is the next best thing to a single protocol network. Efficiency suffers however when translation or encapsulation of various protocols is required before passing through the network.

The most efficient network processing occurs when a single protocol is used for the Enterprise Network. This is the ideal, but not the most practical solution for an existing network environment.

To provide the best possible efficiency for the Enterprise Network, it is proposed that the County adopt a plan to standardize the backbone network on a single protocol. Today the de facto standard protocol for Enterprise Networks is TCP/IP.

This does not dictate the protocol of choice for Local Area Networks. These networks will continue to operate with the protocols best suited for the LAN. This proposal suggests an interface at the server that will communicate with the Enterprise Network in TCP/IP protocol, and with the LAN in the protocol designed for the LAN.

The following section is a description of the primary protocols used in the County and how the network will work with them in the future.

SNA Traffic Strategy:

As mentioned in the Technical Requirements section of this document, SNA traffic will not likely disappear in the near term. Most likely SNA traffic will play a long term role in the County network Architecture for some mission critical data/applications. Figure 3.1 shows the current SNA and TCP/IP environment of today.

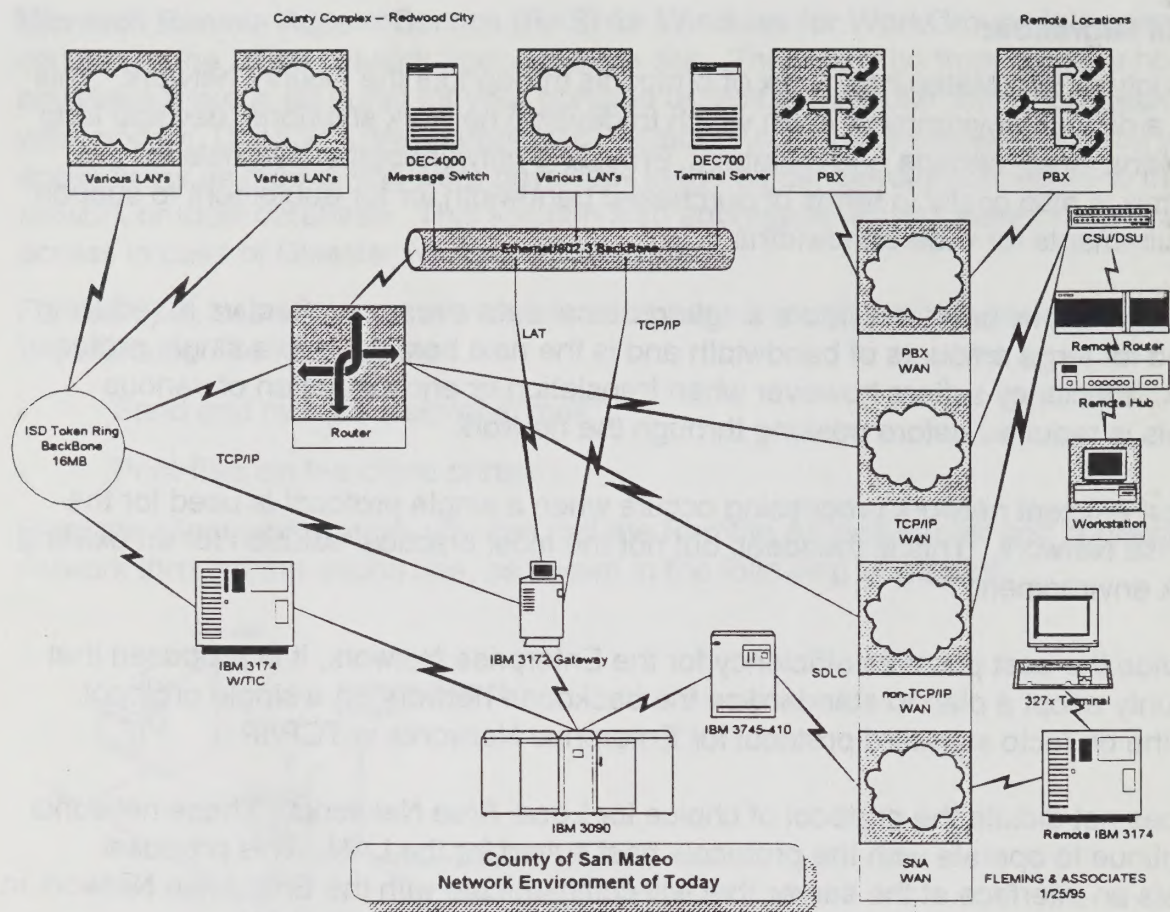


Figure 3.1

San Mateo County has taken the initial steps toward implementation of open and distributed systems based on TCP/IP, and is developing systems based on this technology.

TCP/IP is the preferred protocol for network migration and integration of SNA into this protocol is necessary for future implementation of the Enterprise Network Architecture strategy for the County. SNA over IP supports non-disruptive high-performance route switching.

ATM-based networking will ultimately be the choice for the County Infrastructure. IBM is exploiting its product performance across all seven OSI layers, including ATM technology development currently estimated at over \$100 million annually.

The County has a predominant IBM environment with the potential of ongoing SNA traffic. IBM is positioning themselves as a major vendor for the ATM market. The County of San Mateo is advised to continue to review IBM announcements and network product offerings.

In the interim, as the County increases the TCP/IP environment throughout the County it will be necessary to begin integration of SNA traffic into the TCP/IP traffic flow. This process of encapsulation of SNA-SDLC traffic in IP data packets through routers is

called SDLC tunneling. When implemented, the environment will migrate as shown in Figure 3.2 below.

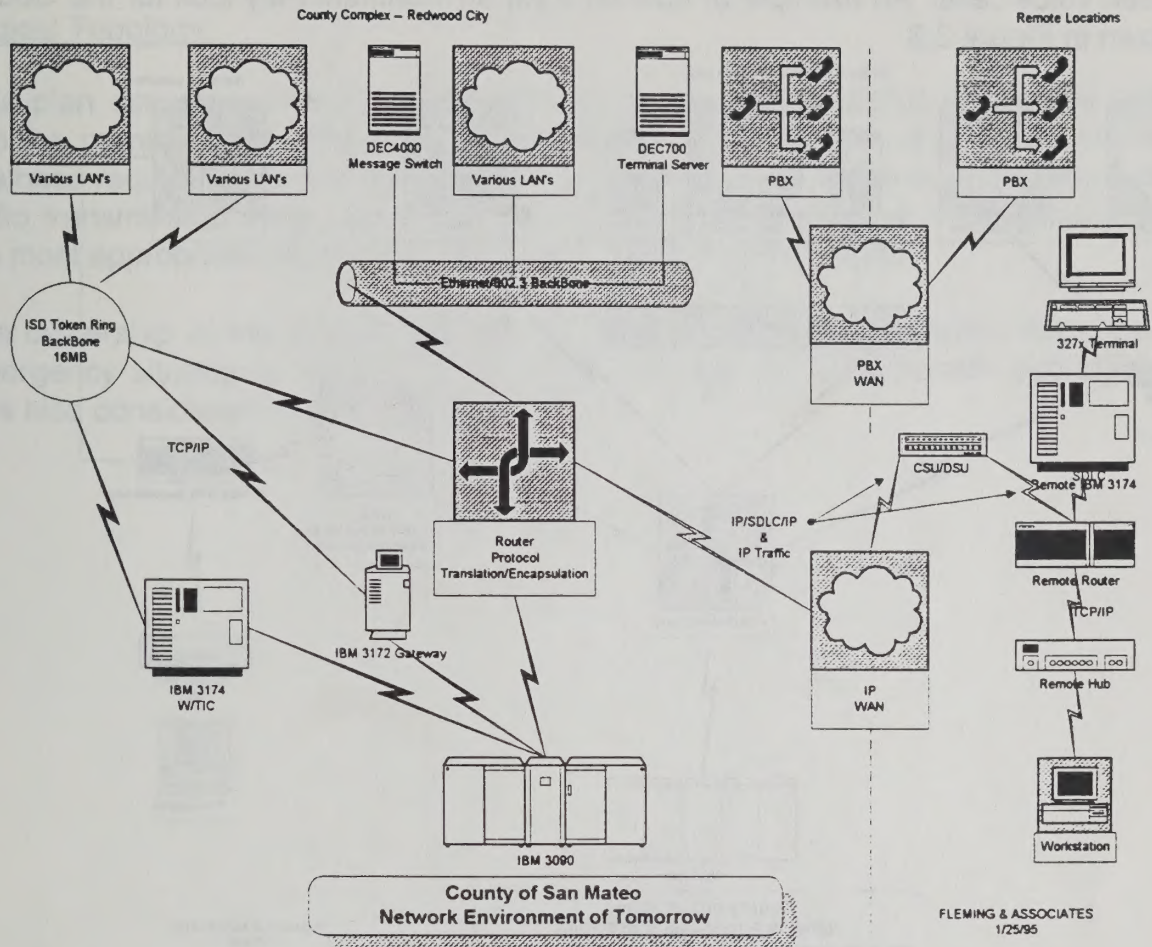


Figure 3.2

As demands for voice, data, radio, and video increase, the need for more bandwidth will inevitably increase as well. This demand will eventually drive the bandwidth usage beyond the capability for the Microwave network. At that time the network can be re-configured to support ATM by replacing routers at key locations with ATM switch technology. This can provide up to a 2 to 1 bandwidth compression from individual channel assignments improving bandwidth usage and providing integration of data, voice, and video.

Cell-Switching technology, based on Asynchronous Transfer Mode (ATM) standards, promises to allow a variety of network applications to efficiently share expensive bandwidth resources.

The optimum solution for the County of San Mateo Enterprise-wide Network Architecture beyond TCP/IP may be an interoperable, portable, protocol that integrates voice, data, and video into the available bandwidth efficiently. ATM provides efficient transport of voice, data, and video maximizing the bandwidth usage.

Along with voice transmission on cell-based transport, this unique transport is capable of providing optimal non-voice applications by using available bandwidth space between voice cells. An example of how an ATM environment may look for the County is shown in Figure 3.3

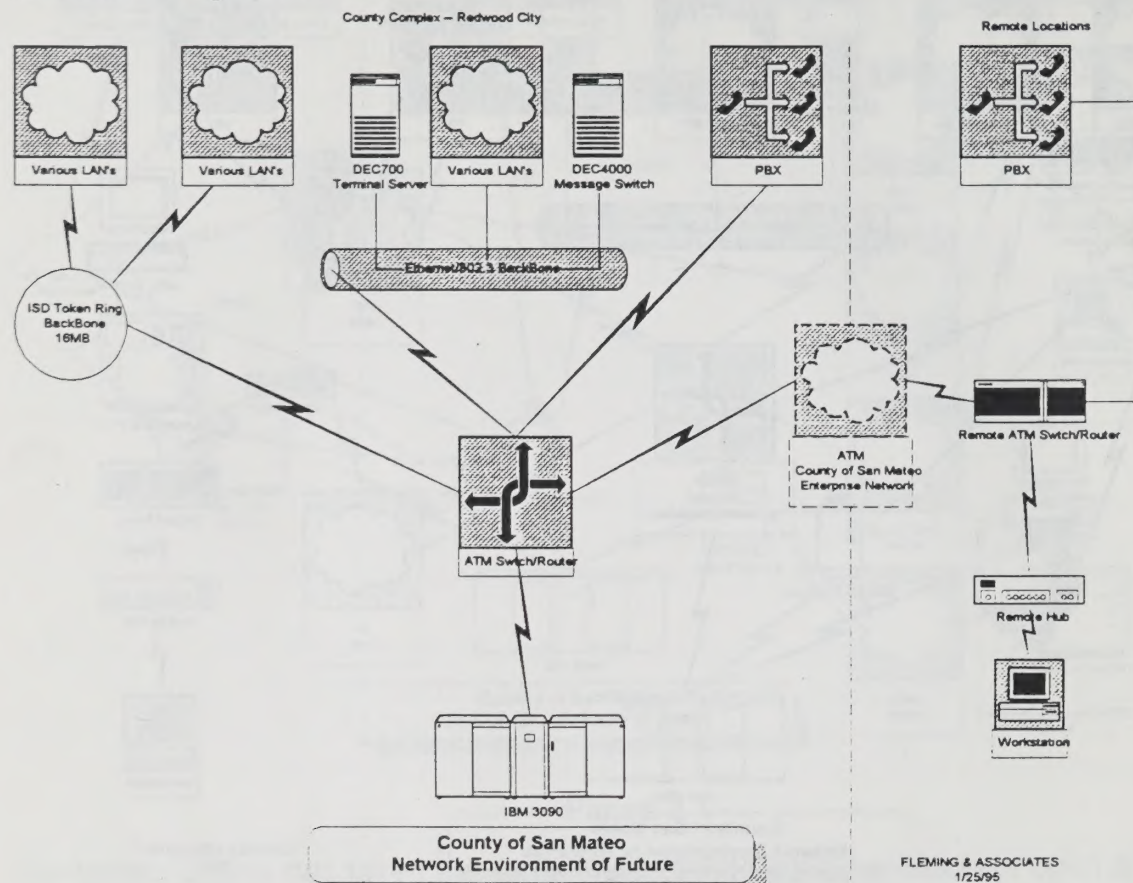


Figure 3.3

Network View Conceptual Backbone Design:

The goal of the County-wide Enterprise Network Architecture is to provide connectivity among County agencies over digital data network links (paths). This produces a communications infrastructure that will improve the capability of County employees to share information, hardware, and software.

This network improves daily productivity, reducing the dependence of the mainframe and its many access links, and provides alternative computing solutions with state-of-the-art technology.

The basis of this technology is the TCP/IP backbone network, connected through router-based mesh network, with redundant paths for better reliability, and the capability to add in modular pieces for future growth.

This project will reduce the complexity of the existing multiple protocol, disparate, networks. This is accomplished by standardizing on industry accepted protocols and

technologies that support the County goal of interoperability and connectivity across the County.

Logical Topology:

This plan assumes leveraging and extending the existing digital Microwave network into the primary Wide Area Network Backbone. On the basis of a review of existing business requirements and the need for on-going support of the public safety two way radio transmission sites. Leveraging on the existing Microwave infrastructure seems the most appropriate strategic facility to build upon for the County.

The ownership of the existing Microwave systems, the need to control the network in emergency situations, and the initial cost to replace the network with public facilities was also considered in the decision.

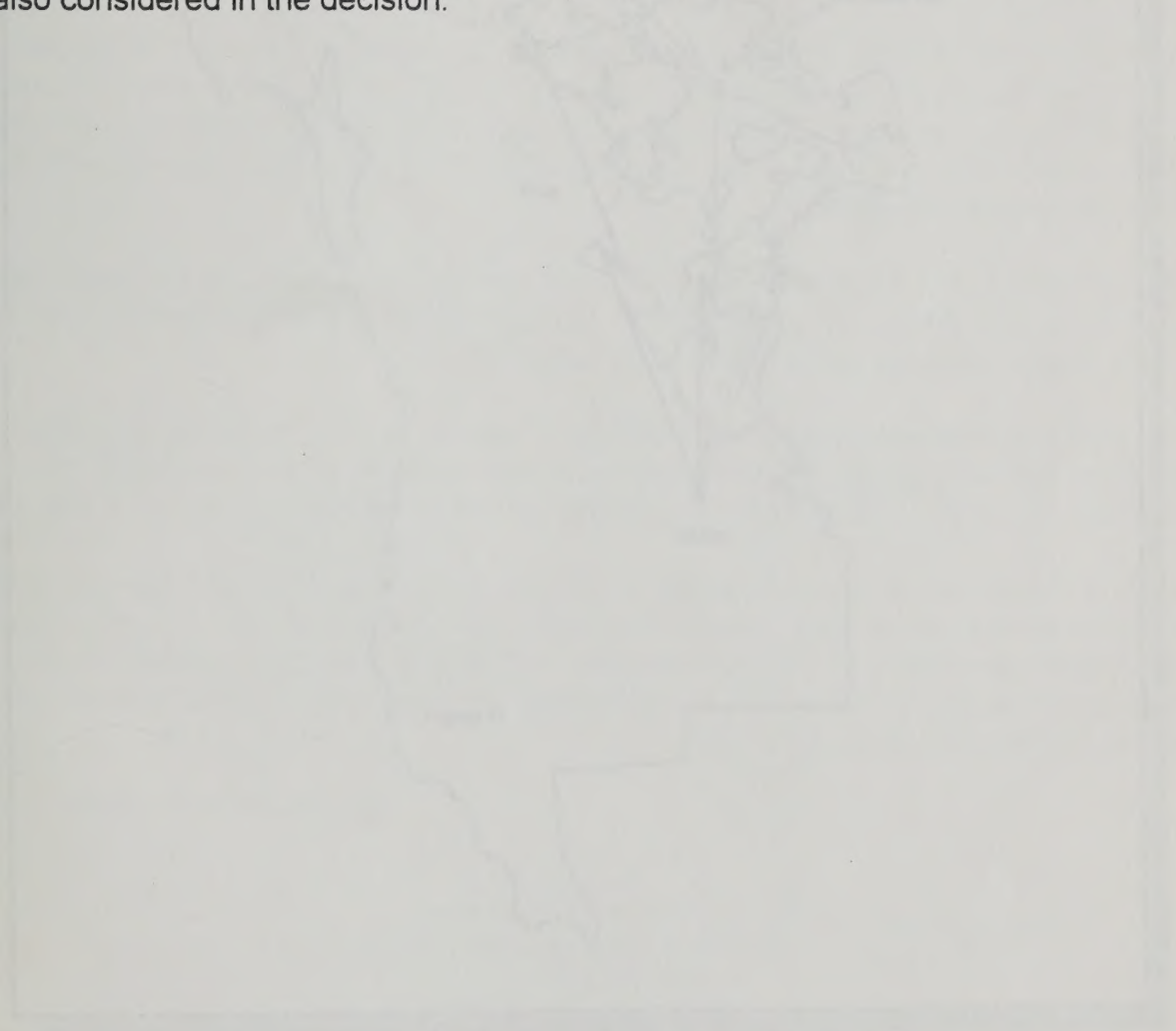


Figure 2.5
San Mateo County Microwave Network

The existing Microwave network will require upgrades to digital systems as outlined in the Western County Countywide Telecommunications Strategic Plan, and the current Public Safety Radio Upgrade project. The secondary backbone network will consist of...

Figure 3.5 shows the current Microwave analog and digital links throughout the County.

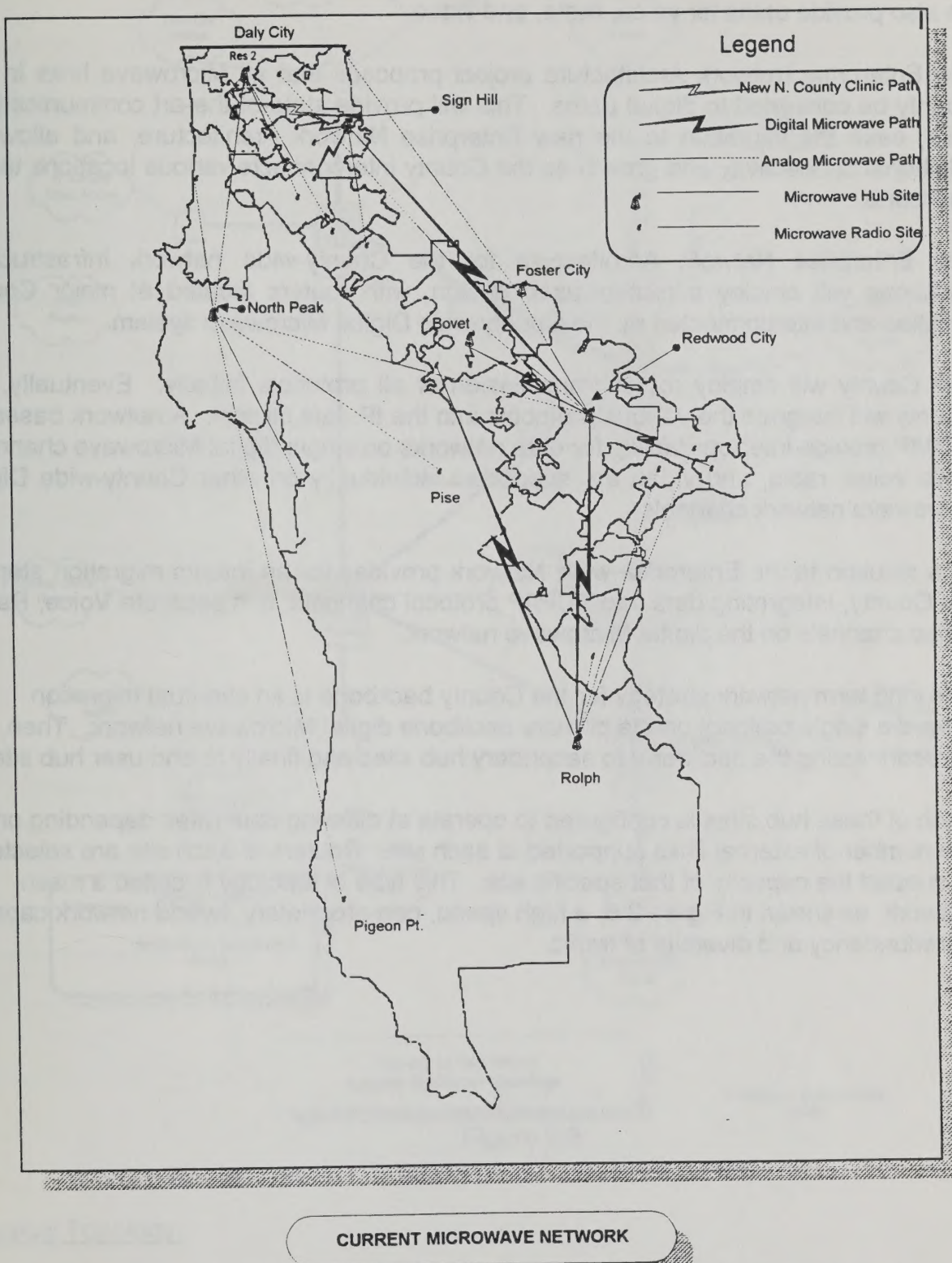


Figure 3.5

The analog Microwave network will require upgrades to digital systems as outlined in the Warner Group County-wide Telecommunications Strategic Plan, and the current Public Safety Radio Upgrade project. The secondary backbone network will need

additional paths via public network systems, such as Frame-Relay, ISDN, or other links to augment the Microwave primary backbone. In providing these digital paths for data, we also provide paths for voice, radio, and video.

The Enterprise Network Architecture project proposes that all Microwave links in the County be converted to digital paths. This will provide state-of-the-art communications links, ease the migration to the new Enterprise Network Architecture, and allow for additional connectivity and growth as the County interconnects various locations to the backbone.

The Enterprise Network Architecture for the County-wide network infrastructure backbone will employ a router-based design, with routers located at major County facilities and interconnected by the County-wide Digital Microwave system.

The County will employ router transmission of all protocols initially. Eventually, the County will integrate the various protocols into the IP data stream. A network based on TCP/IP provide inter-operability for data networks on single digital Microwave channels, while voice, radio, and video are supported individually on other County-wide Digital Microwave network channels.

This solution to the Enterprise-wide Network provides for an interim migration step for the County, integrating data into TCP/IP protocol channels, and separate Voice, Radio, Video channels on the digital Microwave network.

The long term network strategy for the County backbone is an eventual migration toward a single protocol on the primary backbone digital Microwave network. Then, interconnecting the backbone to secondary hub sites and finally to end user hub sites.

Each of these hub sites is configured to operate at differing data rates depending on the number of external links supported at each site. Routers at each site are selected to support the capacity of that specific site. This type of topology is called a mesh network, as shown in Figure 3.6, a high speed, non-proprietary, hybrid network capable of redundancy and diversity of traffic.

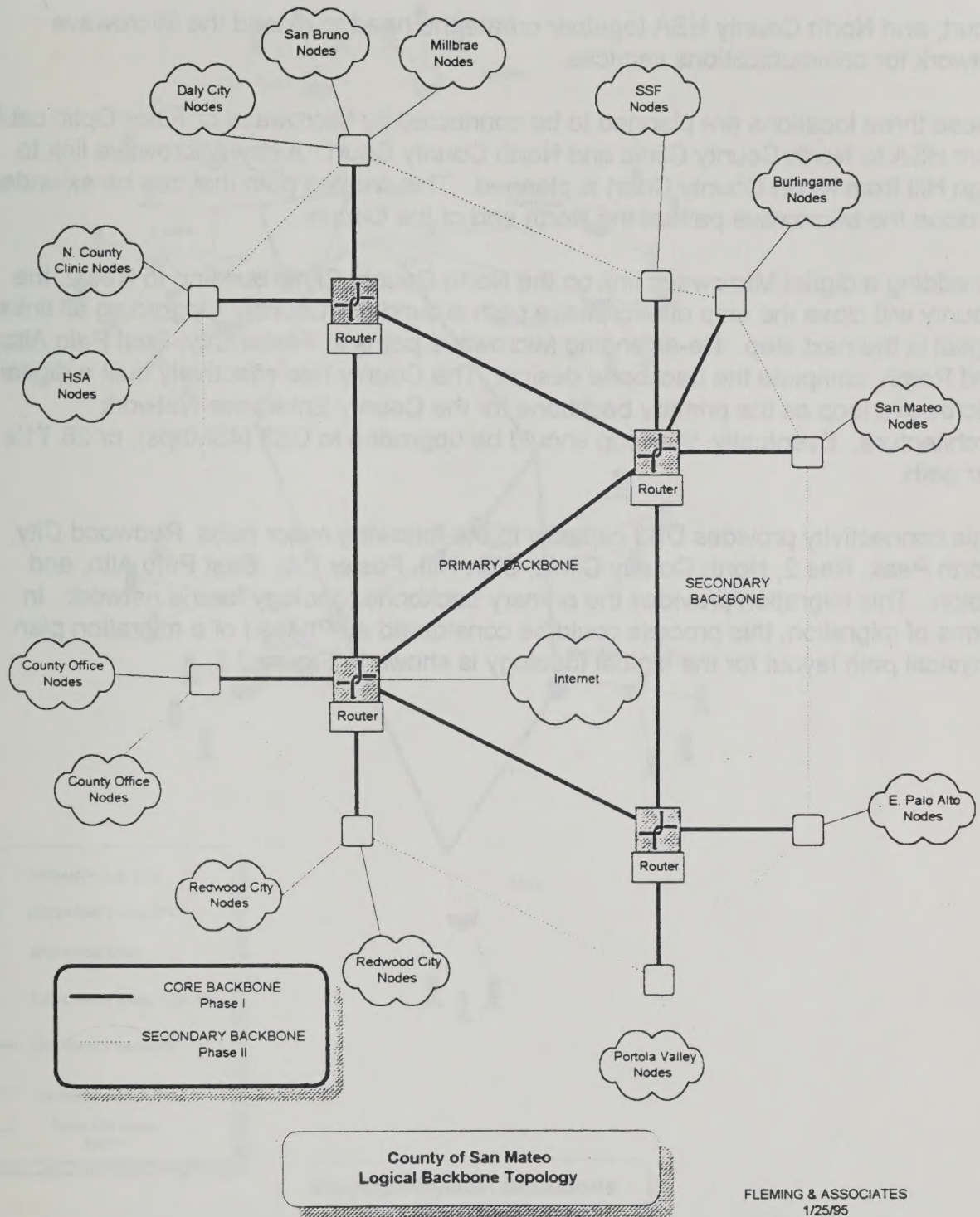


Figure 3.6

Physical Topology:

The topology requires an upgrading and extension of the existing digital Microwave network to create a primary backbone loop at the north end of the County. This is partially accomplished with the addition of the North County Clinic project. In adding that location, and the requirement to connect the North County Clinic, North County

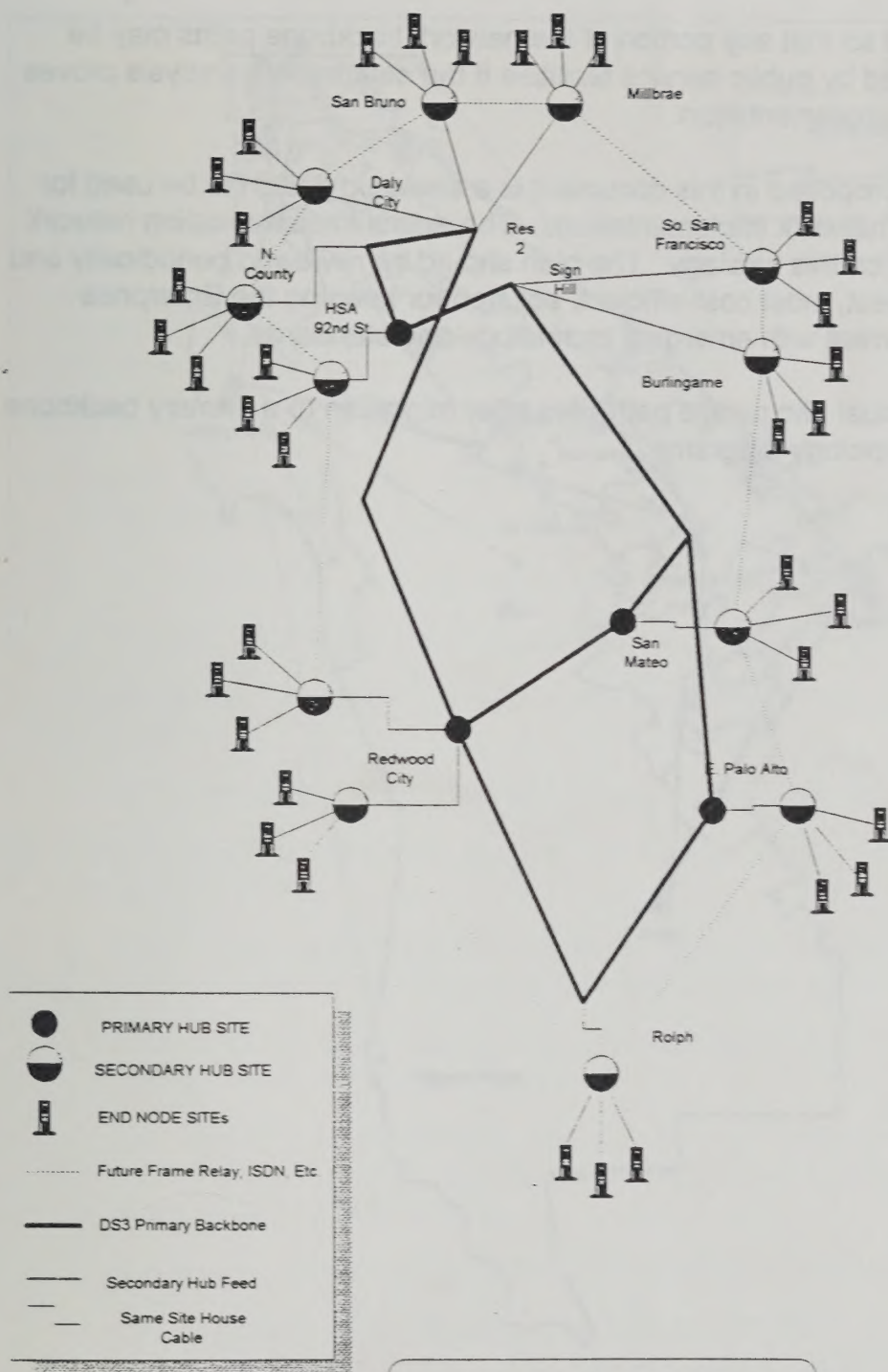
Court, and North County HSA together create the need to extend the Microwave network for communications services.

These three locations are planned to be connected by Microwave or Fiber Optic cable from HSA to North County Clinic and North County Court. A new Microwave link to Sign Hill from North County Court is planned. This creates path that can be extended to close the Microwave path at the North end of the County.

By adding a digital Microwave link on the North County Clinic building to Res 2, the County will close the loop of Microwave path around the County. Upgrading all links to digital is the next step. Re-arranging Microwave paths to Foster City, East Palo Alto, and Rolph, complete the backbone design. The County has effectively built a digital Microwave loop as the primary backbone for the County Enterprise Network Architecture. Eventually, this loop should be upgraded to DS3 (45Mbps), or 28 T1's per path.

This connectivity provides DS3 capacity to the following major hubs: Redwood City, North Peak, Res 2, North County Clinic, Sign Hill, Foster City, East Palo Alto, and Rolph. This migration provides the primary backbone topology for the network. In terms of migration, this process could be considered as Phase I of a migration plan. A physical path layout for the logical topology is shown in Figure 3.7.





County Physical Backbone Topology

Figure 3.7

FLEMING & ASSOCIATES
1/25/95

The network is designed so that any portion of the network backbone paths may be augmented, or substituted by public service facilities if the cost/benefit analysis proves beneficial at the time of implementation.

The conceptual design proposed in this document is a strategic design to be used for planning future detailed network implementations. The actual implementation network design should be based on this strategy. The plan should be reviewed periodically and modified based on the best, most cost efficient, solution for keeping the Enterprise Network Architecture current with emerging technology and standards.

Figure 3.8 shows the actual Microwave path sites after migration to a primary backbone Microwave loop in the topology diagrams.



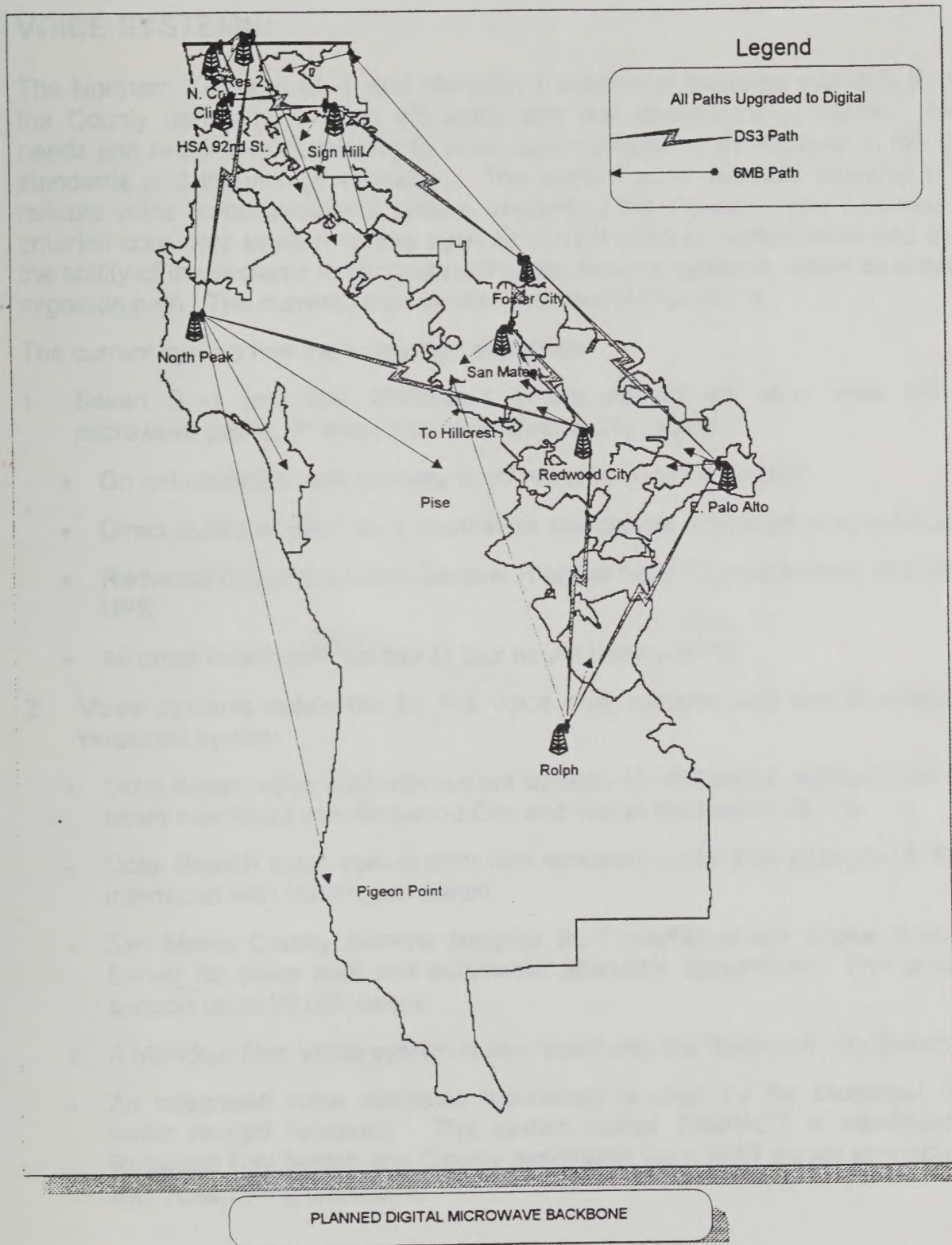


Figure 3.8

VOICE SYSTEMS:

The Northern Telecom SL-1 and Meridian-1 telephone switches installed throughout the County generally function efficiently with few operational problems. Identified needs and requirements relating to voice communications are focused in the areas of standards and technology migration. The current voice network provides a robust, reliable voice communications system throughout the County. The following design criterion considers several factors such as current product performance and flexibility, the ability of the systems to integrate with other existing systems, ability to expand, and migration path. The current voice system is shown in Figure 3.9

The current system has the following capabilities:

1. Seven SL-1 and one Meridian-1 interconnected via land lines and digital microwave paths. Primary Hub at Redwood City facility.
 - On net capability with delivery to off net closest to destination.
 - Direct trunks at each SL-1 location for standalone operation in an emergency.
 - Redwood City and County General Hospital have 12 hour battery and Generator UPS.
 - All other locations have two to four hour's battery UPS.
2. Voice systems supported by five voice mail systems and one integrated voice response system.
 - Octel Aspen voice mail with current capacity for 400 users and maximum to 3000 users interfaced with Redwood City and one at the Harbor SL-1's.
 - Octel Branch voice mail system with maximum expansion capacity of 500 users interfaced with Huntington switch.
 - San Mateo County General Hospital SL-1 interfaced with Digital Sound Voice Server for voice mail and automated attendant capabilities. This product can support up to 20,000 users.
 - A Meridian Mail Voice system is interfaced with the Redwood City Switch.
 - An integrated voice response technology is used by the Municipal Court for traffic related functions. The system called SIMPACT is interfaced to the Redwood City Switch and County mainframe via a SUN server connected to the ISD Token Ring backbone.

Upon reviewing the needs of the County for future voice requirements this document design recommends the following strategy.

Continue upgrading the current SL-1's with Meridian-1 level architecture. Additionally, this design recommends multiple trunk entrance points in the County to provide for redundancy in case of a major catastrophe. With the re-design of the Microwave wide area backbone network, diverse pathing for voice can be considered, and is recommended as part of a redundant design.

Current Voice System Configuration:

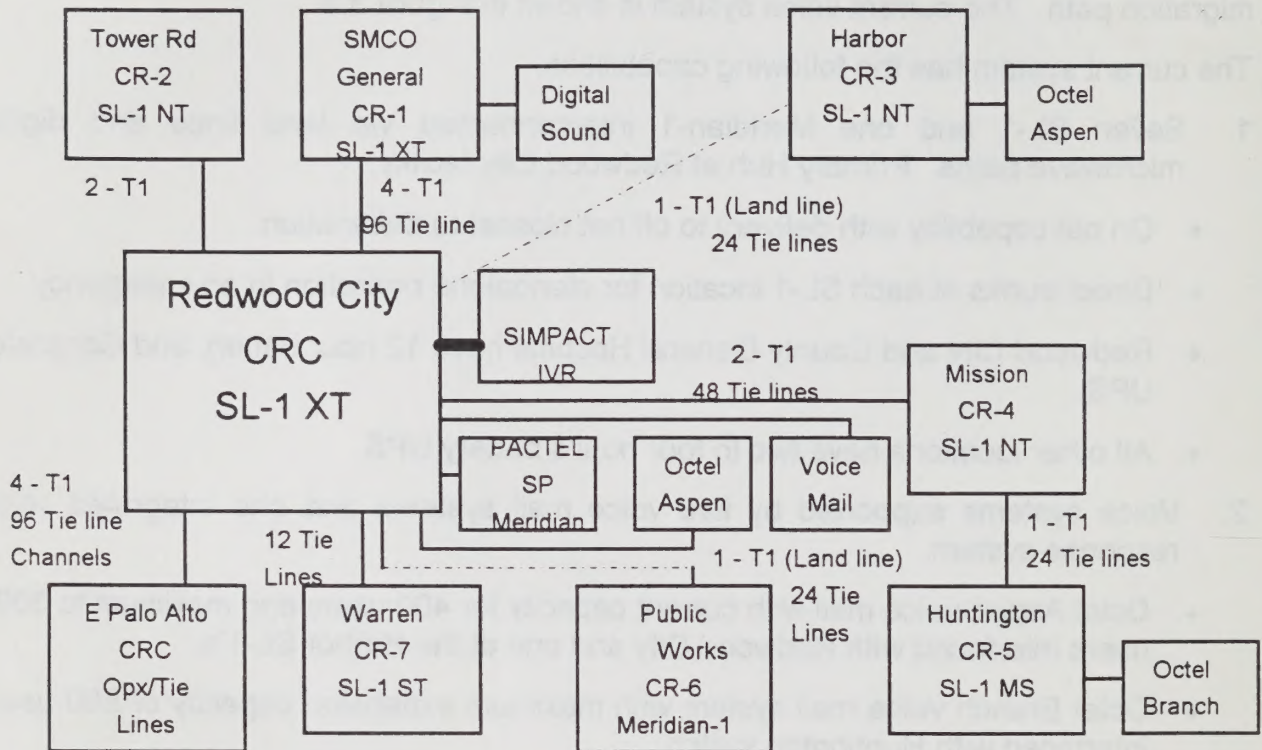


Figure 3.9

When the voice hubs are all at the same software level, implement a virtual voice network, with ISDN connectivity for full functionality of number identification, single system voice mail, and other benefits. Figure 3.10 shows the completed diagram for the upgrades.

Proposed Voice System by Warner Study:

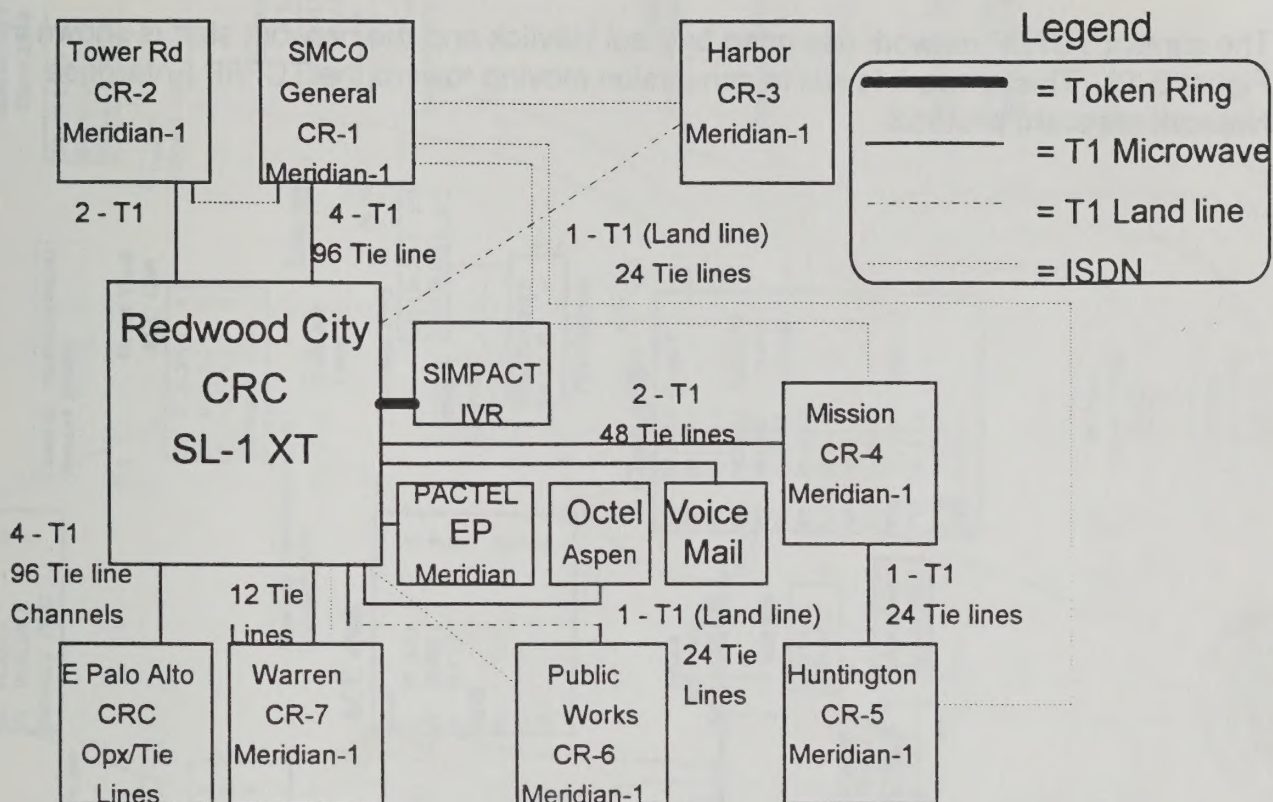


Figure 3.10

A new area code numbering plan was implemented at the beginning of 1995. This new plan requires upgrades to the PBX to recognize the new number scheme. The Meridian level software is capable of supporting this requirement. The County needs to initiate a project to make the required upgrades to support this requirement.

CURRENT IP - MIGRATION NETWORK

The current TCP/IP network designed by Paul Havlick and the network staff is shown in Figure 3.11. This network is still in conversion moving toward the TCP/IP Enterprise Network standard protocol.



Figure 3.11

The current TCP/IP network designed by Paul Havlick and the network staff is shown in Figure 3.11. This network is still in conversion moving toward the TCP/IP Enterprise Network standard protocol.

County of San Mateo New TCP/IP Map

all F/R connections are 56 KB
(North Muni is 128 kb)

Sheriff-Training Cisco 2501 DLCI 26
Serial 10.30.1.16 10301
Ethernet 10.30.140.1 1030140
Circuit ID: 79QEDA952113-001
MAC Addr:

Sheriff-Crimelab Cisco 2501 DLCI 28
Serial 10.30.1.13 10301
Ethernet 10.30.130.1 1030130
Circuit ID: 79QEDA952115-001
MAC Addr:

Central Muni Cisco 2501 DLCI 23
Serial 10.30.1.8 10301
Ethernet 10.30.70.1 103070
Circuit ID: 79QEDA952109-001
MAC Addr:

Animal Control Cisco 2501 DLCI 25
Serial 10.30.1.13 10301
Ethernet 10.30.120.1 1030120
Circuit ID: 79QEDA952112-001
MAC Addr:

Library Cisco 2501 DLCI 27
Serial 10.30.1.12 10301
Ethernet 10.30.110.1 1030110
Circuit ID: 79QEDA952114-001
MAC Addr:

North Muni Cisco 2501 DLCI 29
Serial 10.30.1.9 10301
Ethernet 10.30.80.1 103080
Circuit ID: 79QEDA952651-001
MAC Addr:

HSA Quarry Cisco 2501 DLCI 22
Serial 10.30.1.10 10301
Ethernet 10.30.90.1 103090
Circuit ID: 79QEDA952108-001
MAC Addr:

ISD Test Cisco 2501 DLCI 20
Serial 10.30.1.6 10301
Ethernet 10.30.50.1 103050
Circuit ID: 79QEDA952389-001
MAC Addr: 0000.0c09.95c7

D/A Family Sup. Cisco 2501 DLCI 24
Serial 10.30.1.11 10301
Ethernet 10.30.100.1 1030100
Circuit ID: 65QEDA952111-001
MAC Addr:

Bayshore Cisco 2501 DLCI 17
Serial 10.30.1.3 10301
Ethernet 10.30.20.1 103020
Circuit ID: 65QEDA952329-001
MAC Addr: 0000.0c09.ea75

Pollicita Cisco 2501 DLCI 19
Serial 10.30.1.5 10301
Ethernet 10.30.40.1 103040
Circuit ID: 65QEDA952328-001
MAC Addr: 0000.0c09.98d6

Jefferson Cisco 2501 DLCI 18
Serial 10.30.1.4 10301
Ethernet 10.30.30.1 103030
Circuit ID: 65QEDA952326-001
MAC Addr: 0000.0c09.98cf

Kennedy Cisco 2501 DLCI 16
Serial 10.30.1.2 10301
Ethernet 10.30.10.1 103010
Circuit ID: 65QEDA952327-001
MAC Addr: 0000.0c09.98f6

Retirement Cisco 2501 DLCI 21
Serial 10.30.1.7 10301
Ethernet 10.30.60.1 103060
Circuit ID: 79QEDA952334
MAC Addr: 0000.0c31.9171

HSA
Cisco 4000
TR0 10.21.5.1 10215
TR1 10.21.6.1 10216
E0 10.21.3.1 10213
E1 10.21.4.1 10214
S0 10.21.1.2 10214
S1 10.21.2.1 10213
Network # 10213

County General
Cisco 2514
E0 10.22.3.1 10223
E1 10.22.2.1 10222
S0 10.22.1.2 10223
S1 10.30.1.14 10223
Network # 10223

Circuit ID: 79QEDA952323-001
Network # 10301

Assessor, Tax Collector & Treasurer
Network # 1061 Server Network #

County Manger
Network # 1072

BOS & Clerk of the Board
Network # 1071 Server Network # 9090

Probation
Network # 1081 Server Network #

Controller
Network # 1091 Server Network # 50

Environmental Services and Parks & Rec.
Network # 10101 Server Network #

Circuit ID: 79DADH379876-001
Network # 1020200

Twin Dolphin
ACC 4200

J1 10.20.200.2 S
J2 10.20.20.1 E
J3 10.20.1.2 S
Network # 102020

Circuit ID: 79DADH379876-001
Network # 10201

Remote Node
Communications
Server

IFAS
System
RS/6000

Cisco 7000

S0 10.20.1.1 Future PW
S1 10.21.1.1
S2 10.22.1.1
S3
S4
S5
S6
S7
E0 10.5.1.1 128.1.200.1
E1 10.6.1.1
E2 10.7.1.1
E3 10.8.1.1
E4 10.9.1.1
E5 10.10.1.1
TR0 10.1.1.1 128.1.100.1
TR1 10.2.1.1
TR2 10.3.1.1
TR3 10.4.1.1

San Carlos Airport
ACC 4200

J1 10.20.201.1 S
J2 10.20.2.1 E
J3 10.20.200.1 S
Network # 10202

Circuit ID: 79DADH378936-001
Network # 1020201

T-1 **Grant Yard**
ACC 4200

J3 10.20.201.2 S
J2 10.23.2.1 E
J1 10.23.1.2 S
Network # 10232

Circuit ID: 79DADA379835-001
Network # 10231

ACC 4500

ACS1
J1 10.23.1.1 S
J2 10.20.1.1 S
J3 10.5.1.3 E
ACS2
J1 S
J2 S
J3 E

Internet
To RG NET
Circuit ID: 56 kb

Cisco 2501

140.174.158.1 S
140.174.135.1 E

DNS
Server

140.174.135.2 E
10.5.1.20 E

PIX Gateway

Cisco AGS+

S0 10.30.1.1 Future #
S1 10.25.1.1
S2 10.24.1.1
S3 10.23.1.1 Future PW
E0 10.5.1.2 128.1.200.2
E1 10.14.1.1 128.1.200.1
E2 10.15.1.1
E3 10.16.1.1
E4 10.17.1.1
E5 10.18.1.1
TR0 10.1.1.2 128.1.100.2
TR1 10.11.1.1
TR2 10.12.1.1
TR3 10.13.1.1

Sheriff SWP
Cisco 2510

E0 10.25.2.1
S0 10.25.1.2
Network # 10252

Circuit ID:
Network # 10251

Hillcrest Probation
Cisco 2510

E0 10.24.2.1
S0 10.24.1.2
Network # 10242

Circuit ID: Microwave
Network # 10241

911, OES & ISD
Old Ethernet Backbone 128.
Network # 1281200 Server Network

Network # 10151 Server Netw

Network # 10161 Server Netw

Network # 10171 Server Network # 7

Superior Court Clerk & Mun
Network # 10181 Server Netw

ISD Test
Network # 10131
10.13.1.0

Planning
Network # 10121
10.12.1.0

EPS / Purchasing
Network # 10111
10.11.1.0

Recorder & Assessor
Network # 1031
10.3.1.0

ISD
Network # 1021
10.2.1.0

Data Center
Token-Ring Backbone
Network # FFF100
10.1.1.0
128.1.100.0

DA's
AS/400

Treasurer's
AS/400

J&L Dial-in
Server

Figure 3.11

MIGRATION - IP ADDRESSING CONVERSION

General Instructions

NOTE : ISD is reserving the first 20 IP addresses from each subnet for network devices such as hubs, routers, shared systems, etc. (ex. 10.16.1.1 - 20)
Please start numbering your nodes starting with node number 21 to 40 for printers and servers, and 41 to 254 for PCs / workstations.

Each segment on the network will be assigned an IP address or subnet of 254 possible nodes. Of these ISD is reserving 20 for network devices consequently there are only 234 possible connections available on each subnet. When several departments share a subnet they will be assigned a range of IP numbers to use.

Router Instructions

1. Add secondary IP address to the router port
2. Convert IP addresses on individual workstations and systems
3. Remove secondary IP address from the router port

PC Instructions

1. Change *IP address* in the NET.CFG (from 128.x.x.x to 10.x.x.x)
2. Change *IP router* in the NET.CFG (from 128.x.x.x to 10.x.x.x)
same as your IP address but it end with a number 1
3. Add DNS server name and IP address information in the RESOLV.CFG file. (*future reference*)

Sample NET.CFG file

Link Support

Buffers 8 4500
MemPool 4096
Max Boards 2



Protocol TCP/IP

PATH TCP_CFG C:\AIR\TCP

ip_address 10.16.1.45

(location of your TCP/IP software)

ip_router 10.16.1.1

Changes that need to be made to

these fields

ip_netmask 255.255.255.0

- does not change

tcp_sockets 8

udp_sockets 8

raw_sockets 1

nb_sessions 4

nb_commands 8

nb_adapter 0

nb_domain

IPX RETRY COUNT=100
SPX ABORT TIMEOUT=2000
FILE HANDLES=100
LOCAL PRINTERS=1
PREFERRED SERVER=ISD
CACHE BUFFER=0

(your server name)

Sample RESOLV.CFG file

domain BUDGET
nameserver 128.1.200.21

NOTE

1. The nameserver 128.1.200.21 is the IP address of the DNS server. It is the IP address of the DNS server that is configured on the client machine. The IP address of the DNS server is 128.1.200.21.

2. The domain BUDGET is the domain name of the client machine. It is the domain name that is configured on the client machine. The domain name is BUDGET.

Departmental Conversion Dates

Department	LAN / Systems Administrator	Conversion (1/9/95 - 1/20/95)
Clerk of the Board	Elaine Walton-Horsley	
Controller	Bill Marion Kathleen Welch	
OES	Joe Horton	
911	Robert Bustichi	
Superior Court Clerk	Dan O'Brien	
County Manager	Gail Brahy	
Sheriff	Noyd Cooper	
Parks and Recreation	Gary Lockman	
Environmental Services	Andrew Lee	
HSA	Dan Laden	
Public Works	Tito Olazabal	
EPS / Purchasing	Belle Sierra	
Planning	Angus Ahanotu	
ISD	Carole Lawrence	
Animal Licensing	Connie Urbanski	
ISD Budget System RS/6000	Tony Pham	
ISD Mainframe 3090	Ed Lusnich	
ISD 3172 Controllers	Steve Barretta	

IP Address Range

Department	Servers & Printers	PCs
Clerk of the Board / Board of Supervisors	10.7.1.21 - 30	10.7.1.41 - 120
Controller	10.9.1.21 - 40	10.9.1.41 - 254
OES & 911	10.14.1.21 - 40	10.14.1.41 - 254
Muni Court	10.18.2.31 - 40	10.18.2.121 - 254
Superior Court Clerk	10.18.1.21 - 30	10.18.1.41 - 120
County Manager	10.7.2.31 - 40	10.7.2.121 - 254
Sheriff	10.17.1.21 - 40	10.17.1.41 - 254
Parks and Recreation	10.10.1.31 - 40	10.10.1.121 - 254
Environmental Services	10.10.1.21 - 30	10.10.1.41 - 120
HSA	10.21.3.21 - 40 E0	10.21.3.41 - 254
	10.21.4.21 - 40 E1	10.21.4.41 - 254
	10.21.5.21 - 40 TR0	10.21.5.41 - 254
	10.21.6.21 - 40 TR1	10.21.6.41 - 254
Public Works <i>Twin Dolphin</i> <i>San Carlos Airport</i> <i>Grant Yard</i>	10.20.20.21 - 40	10.20.20.41 - 254
	10.20.2.21 - 40	10.20.2.41 - 254
	10.23.2.21 - 40	10.23.2.41.254
EPS / Purchasing	10.11.1.21 - 40	10.11.1.41 - 254
Planning	10.12.1.21 - 40	10.12.1.41 - 254
ISD	10.2.1.21 - 40	10.2.1.41 - 254
Animal Licensing	10.30.120.21 - 40	10.30.120.41 - 254
Hillcrest	10.24.2.21 - 40	10.24.2.41 - 254
Sheriff SWP	10.25.2.21 - 40	10.25.2.41 - 254
County General	10.22.2.21 - 40 E1	10.22.2.41 - 254
	10.22.3.21 - 40 E0	10.22.3.41 - 254
Assessor & Tax Collector	10.6.1.21 - 30	10.6.1.41 - 120
Treasurer	10.6.2.31 - 40	10.6.2.121 - 254
Probation HOJ	10.8.1.21 - 40	10.8.1.41 - 254
ISD Test	10.13.1.2 - 254	10.13.1.2 - 254

NOTE:

ISD is reserving IP numbers 1 - 20 for network devices such as hubs and router ports.
 Use IP numbers 21 - 40 for servers and printers.
 Use IP numbers 41 - 254 for PCs.

IPX, IP and SNA connectivity should be checked (as applicable) for all PC / workstations with in each department after the conversion is complete.

Controller

LAN Administrator:

Bill Marion 1167
Kathleen Welch

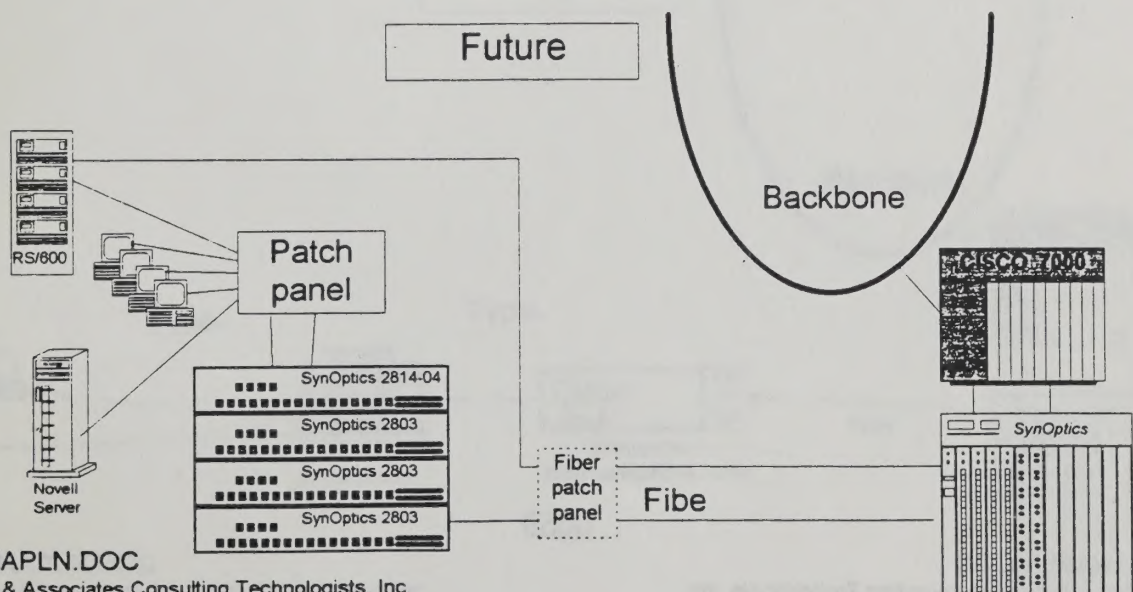
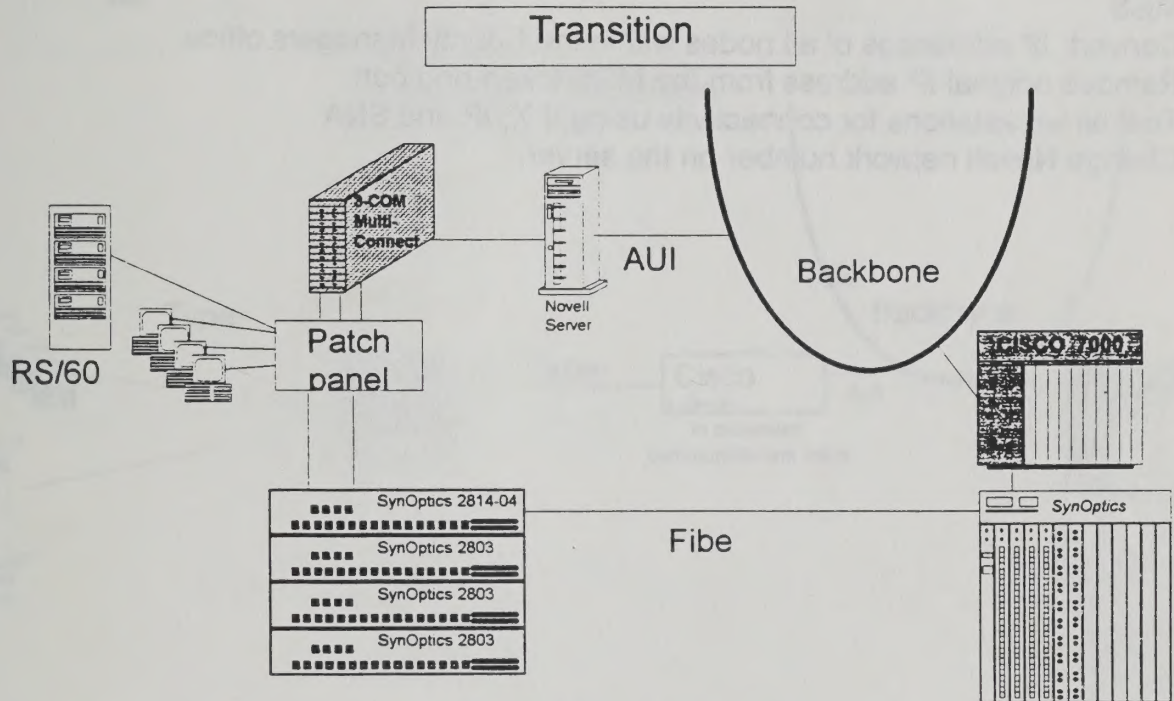
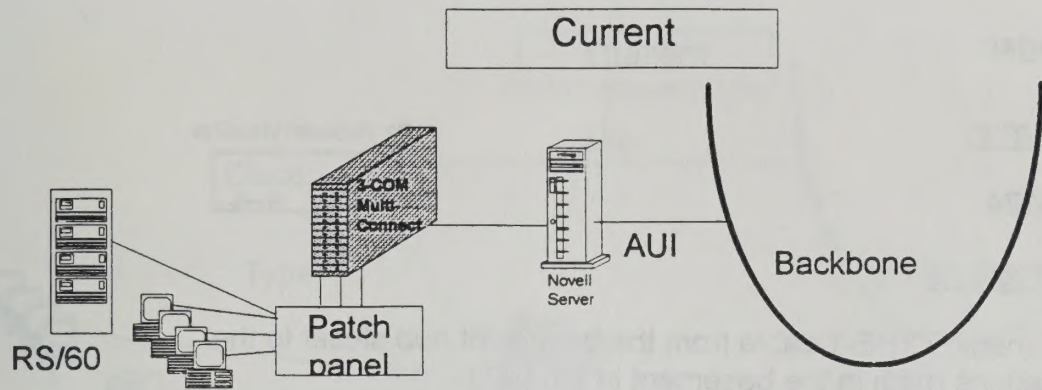
Migrations Instructions

Install new/fiber connectivity

1. Install & terminate fiber runs between the Fiscal Building (FB) and the County Office Building (COB).
2. Install & terminate fiber risers to the third floor closet and computer room in the FB.
3. Install 10 level-5 runs from the 3rd floor closet to the controllers computer room.
4. Install 1 2814-04 hub & 3 2803 hubs in the 19" rack in the 3rd floor closet in FB.
5. Cross connect fiber & test connections from the data center to the FBs 3rd floor closet.
6. Assign IP address and configure Cisco 7000 ethernet port E4 for the controllers LAN.

Transition to new segment

1. Move users one-by-one to the new hubs and change their NET.CFG file Node IP, Router interface IP and check the MASK.
2. Move Novell server to the new hubs and remove routing statements from the AUTOEXEC.NCF .
3. Change Novell network number on the server.
4. Move the RS/6000 to the new hubs and change its IP address as well as all nodes using it.
5. Connect secondary ethernet card in RS/6000 to the new ethernet backbone.



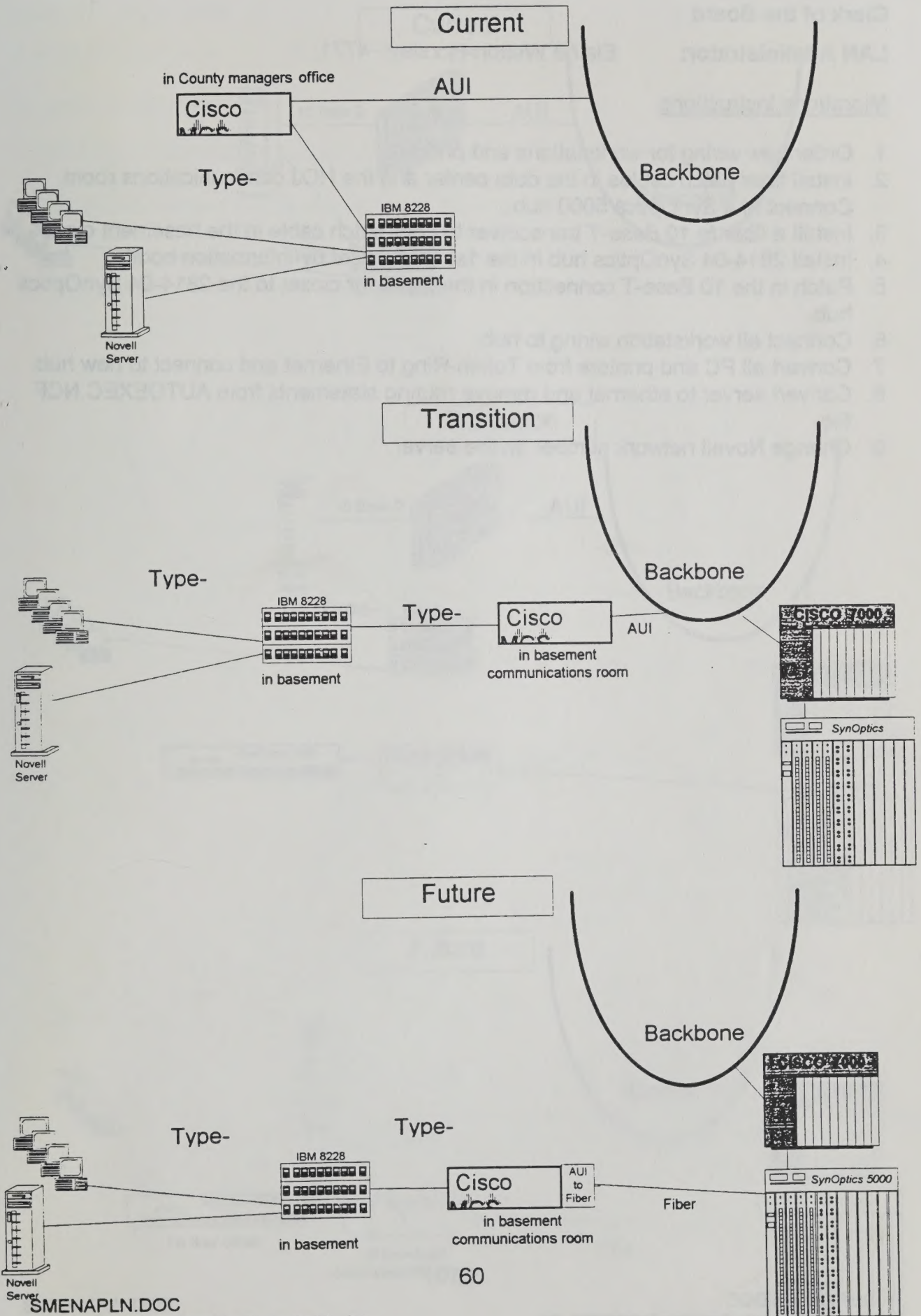
County Manager

LAN Administrator:

Gail Brahy 4124

Migration Instructions

1. Order and install TYPE-1 cable from the basement hub closet to the communications room in the basement in the HOJ
2. Move MGS router to the communications room and test connectivity.
3. Change IP addresses on the MGS ethernet interface to its new address and move connection to fiber . Add a new secondary IP to the token-ring interface on the MGS.
4. Convert IP addresses of all nodes within the County Managers office.
5. Remove original IP address from the MGS token-ring port.
6. Test all workstations for connectivity using IPX, IP and SNA
7. Change Novell network number on the server.

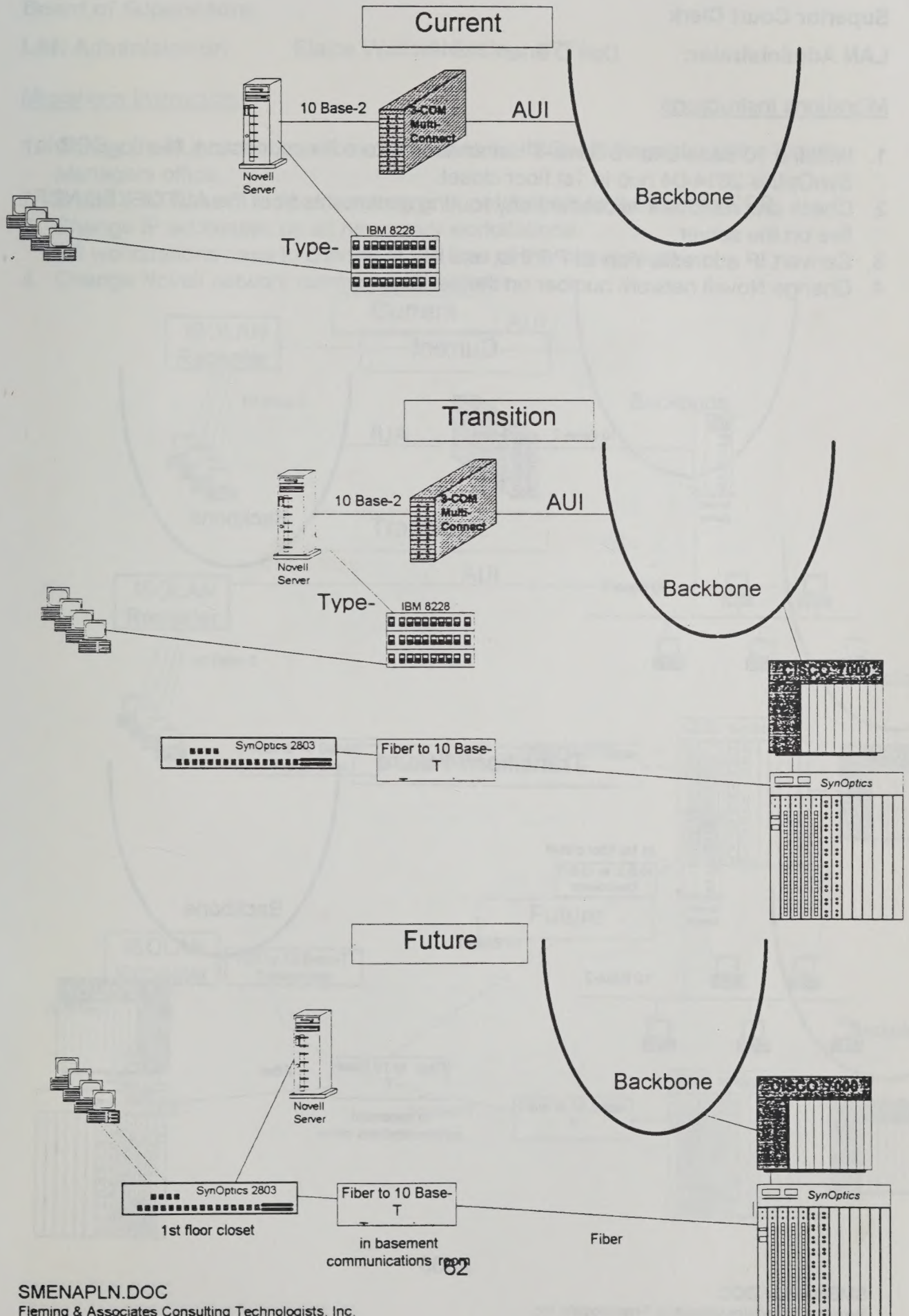


Clerk of the Board

LAN Administrator: Elaine Walton-Horsley 4771

Migrations Instructions

1. Order new wiring for workstations and printers.
2. Install fiber patch cables in the data center and the HOJ communications room.
Connect to a SynOptics 5000 hub.
3. Install a *fiber to 10 Base-T* transceiver to fiber patch cable in the basement closet.
4. Install 2814-04 SynOptics hub in the 1st floor closet by information booth.
5. Patch in the 10 Base-T connection in the first floor closet to the 2814-04 SynOptics hub.
6. Connect all workstation wiring to hub.
7. Convert all PC and printers from Token-Ring to Ethernet and connect to new hub.
8. Convert server to ethernet and remove routing statements from AUTOEXEC.NCF file.
9. Change Novell network number on the server.

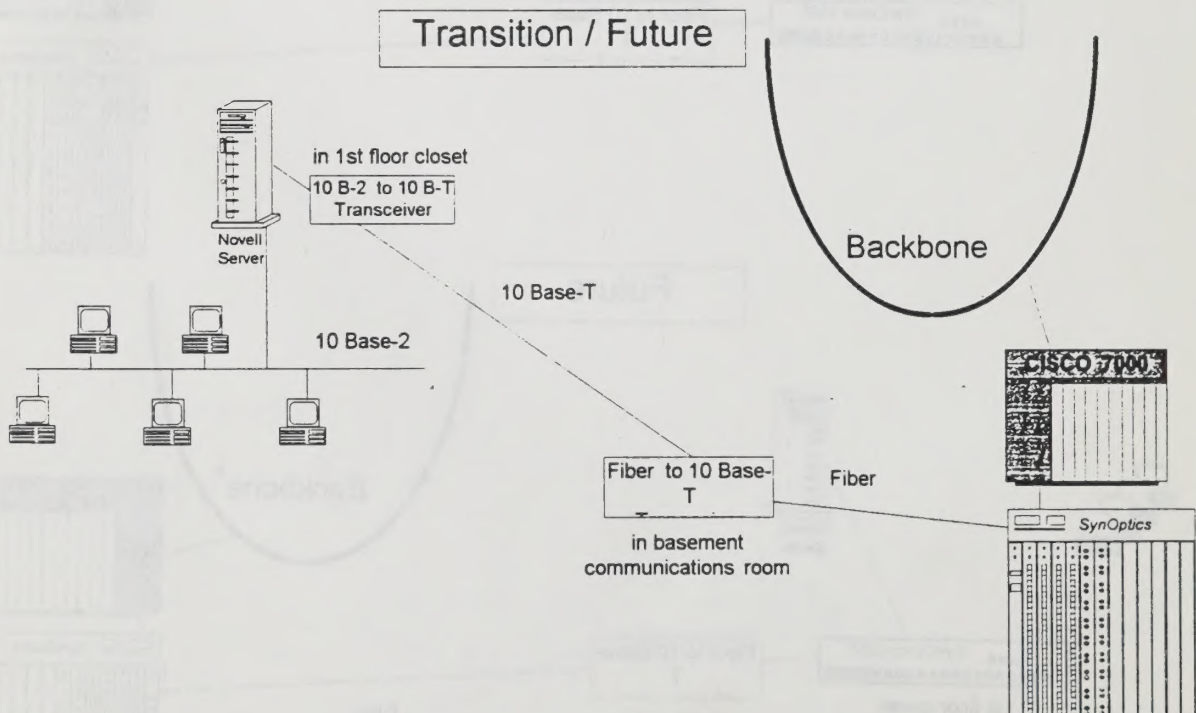
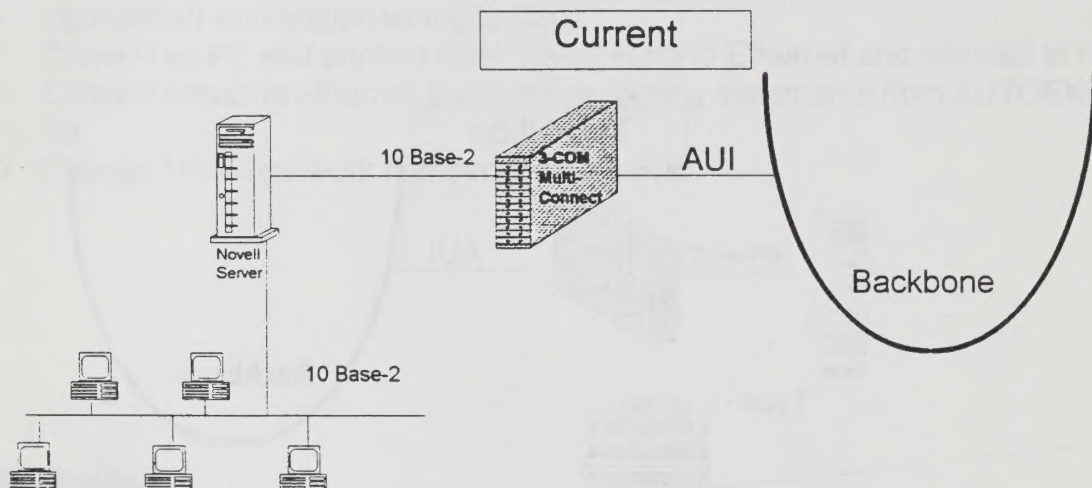


Superior Court Clerk

LAN Administrator: Dan O'Brien 4940

Migrations Instructions

1. Install a 10 Base-2 to 10 Base-T transceiver onto coax connecting Merlin_CCR to SynOptics 2814-04 hub in 1st floor closet.
2. Check and remove if necessary any routing statements from the AUTOEXEC.NCF file on the server.
3. Convert IP addresses on all PC that use IP.
4. Change Novell network number on the server.

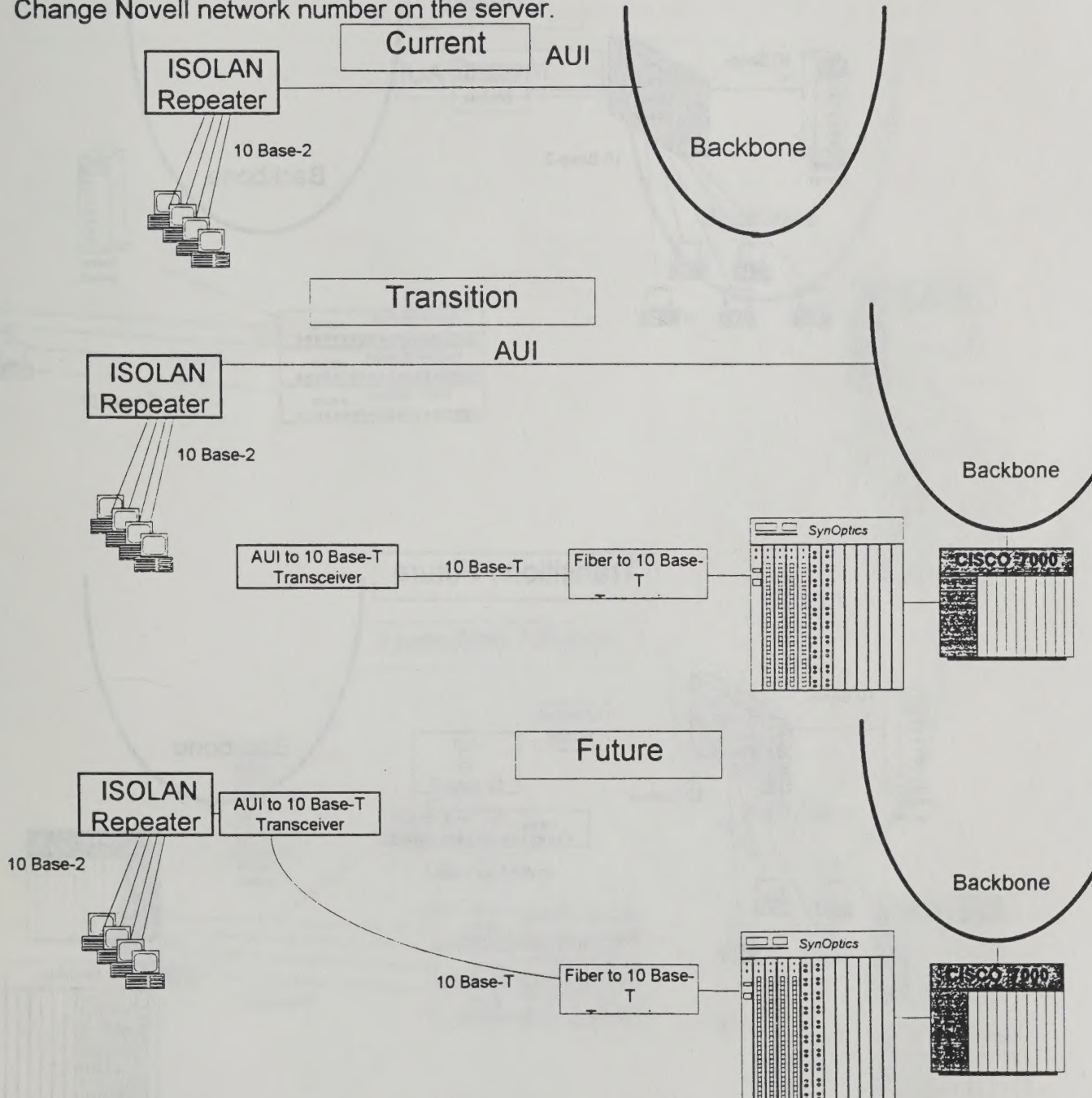


Board of Supervisors

LAN Administrator: Elaine Walton-Horsley 4771

Migrations Instructions

1. Connect a AUI-to-10 base-T transceiver to the ISOLAN Repeater in the County Managers office.
2. Install a 10 Base-T to fiber transceiver to patch them to the fiber to COB.
3. Change IP addresses on all necessary workstations.
(all workstations have to change at the time of the conversion)
4. Change Novell network number on the server.

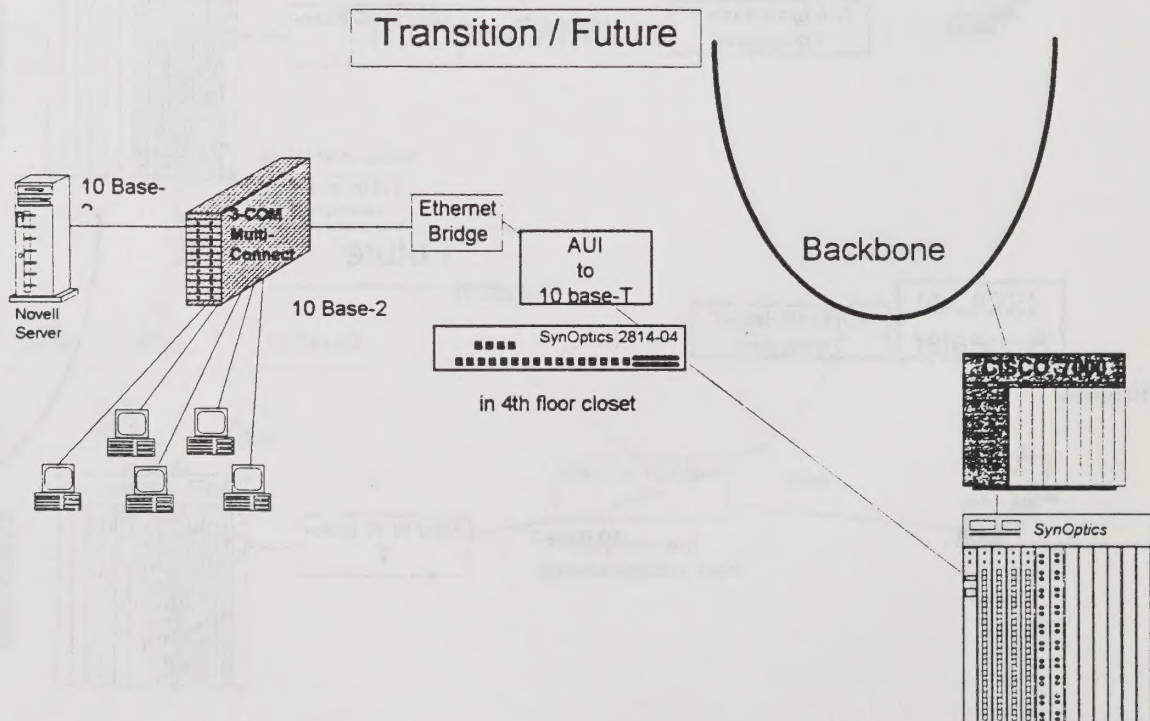
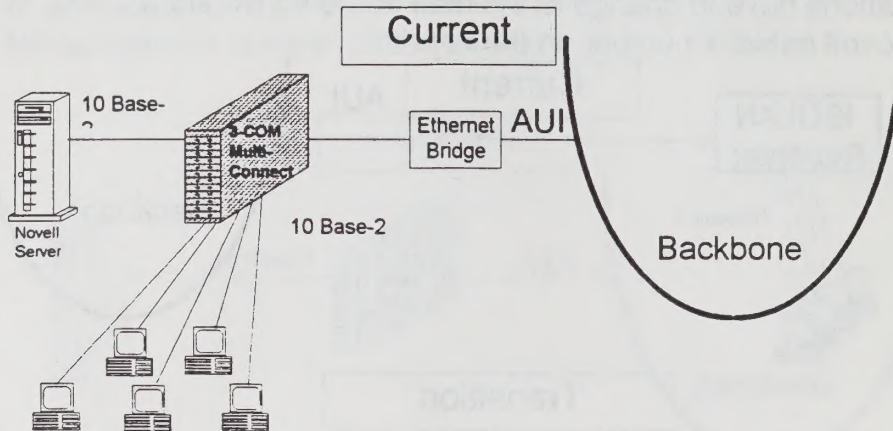


Parks & Rec.

LAN Administrator: Gary Lockman 1881

Migrations Instructions

1. Install AUI to 10 Base-T transceiver on the ethernet bridge.
2. Change IPX network # on server and disable routing *if present*.
3. Convert IP addresses on 2 PCs (Louis & Gary).
4. Change Novell network number on the server.

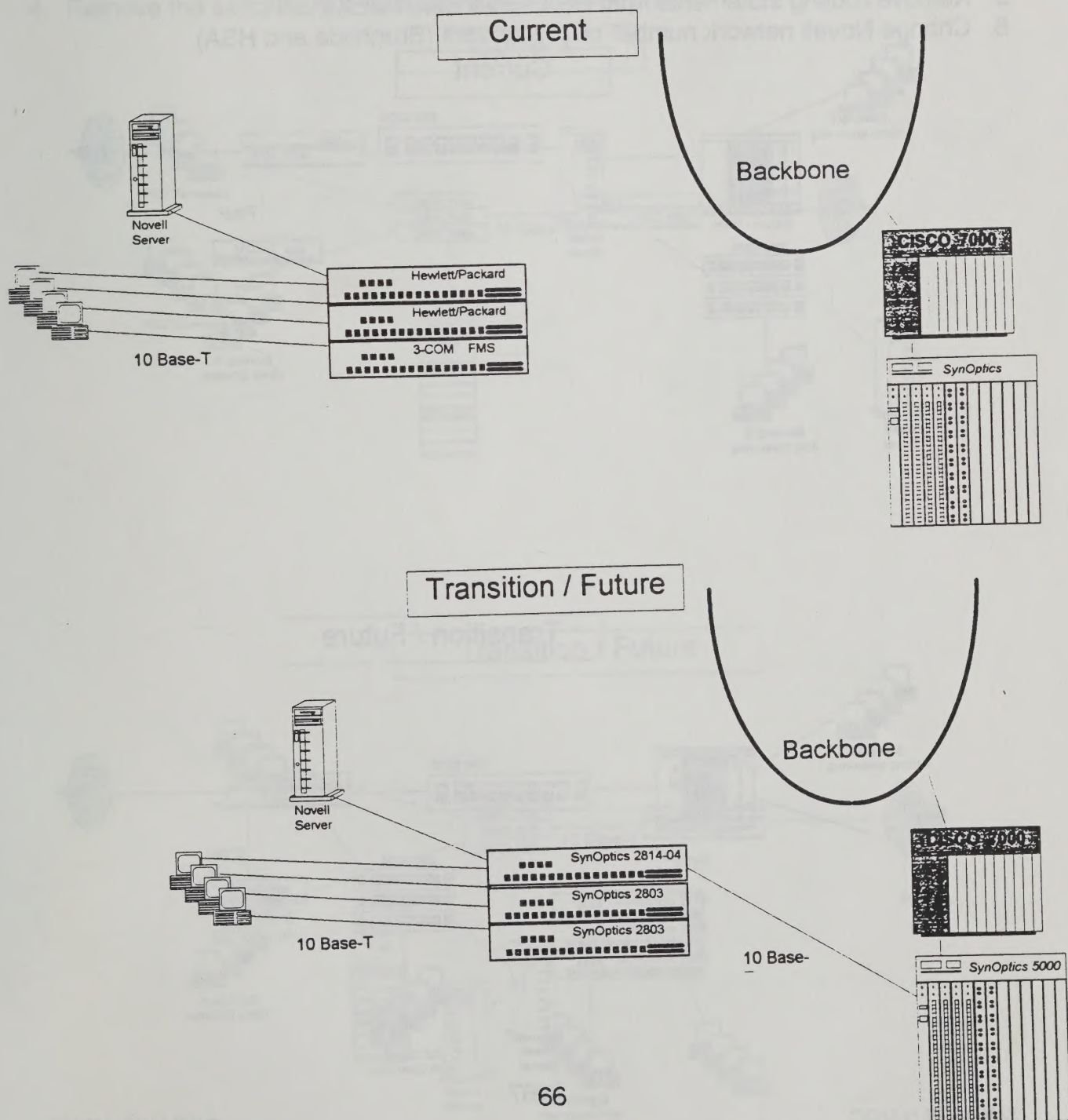


Environmental Services

LAN Administrator: Andrew Lee 2714

Migration Instructions

1. Transition user workstations to new fourth floor hubs.
2. Change IP addresses on all necessary workstations .
(all workstations have to change at the time of the conversion)
3. Change Novell network number on the server.

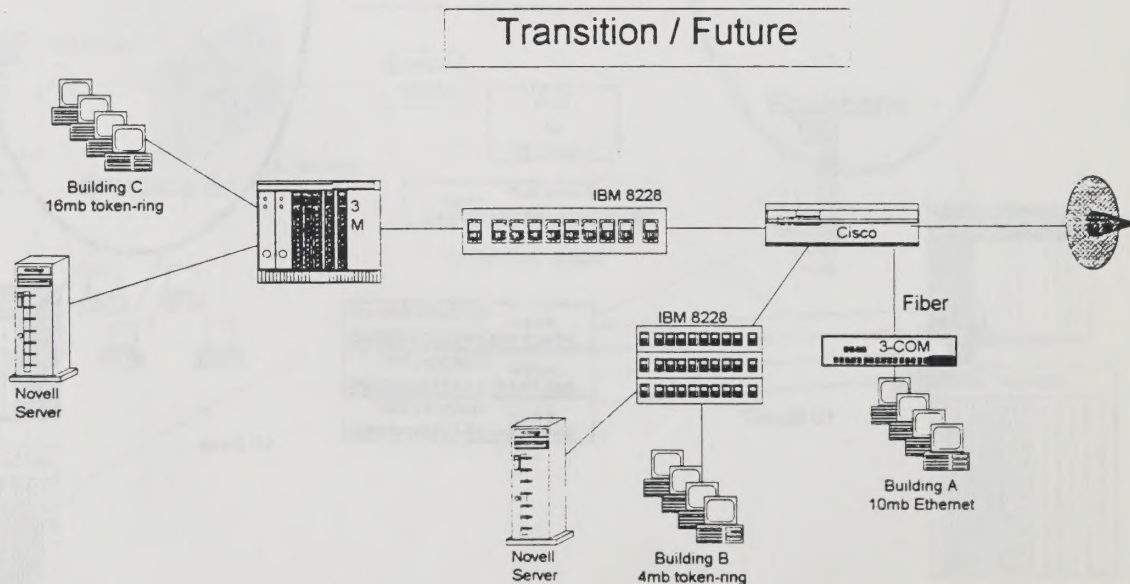
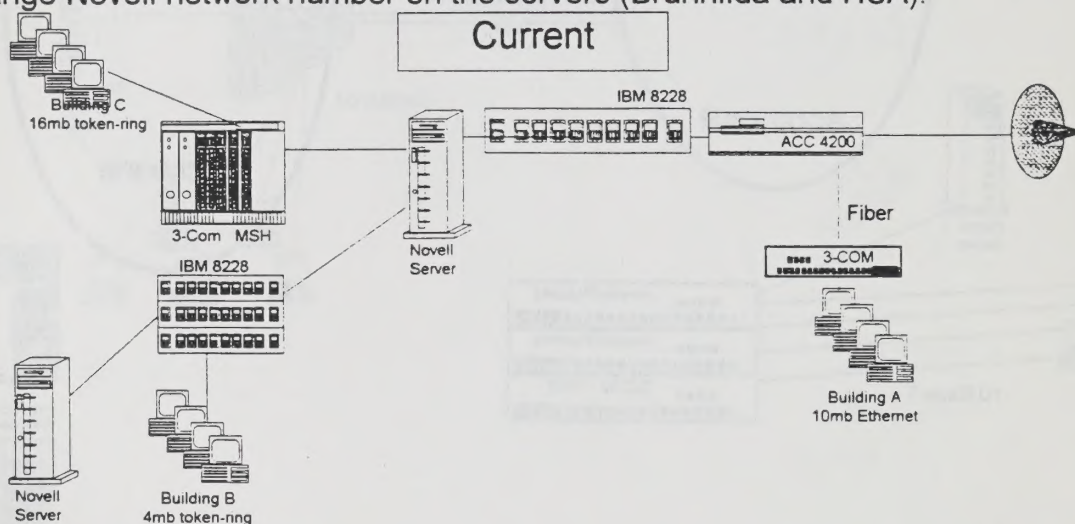


HSA

LAN Administrator: Dan Laden

Migration Instructions

1. Order a serial card & token ring card for the Cisco 4000 router. Install and configure.
2. Install Cisco 4000 router in place of HSA's ACC 4200.
3. Change IP addresses on all necessary workstations.
(all workstations have to change at the time of the conversion)
4. Connect building B to a separate router port.
5. Remove routing statements from HSA servers AUTOEXEC.NCF .
6. Change Novell network number on the servers (Brunhilda and HSA).



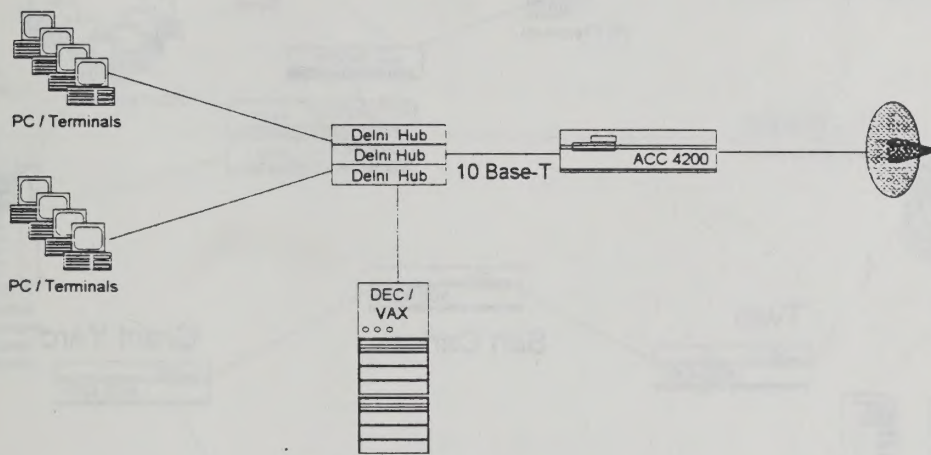
County General

LAN Administrator: Matt Mauzey 2392

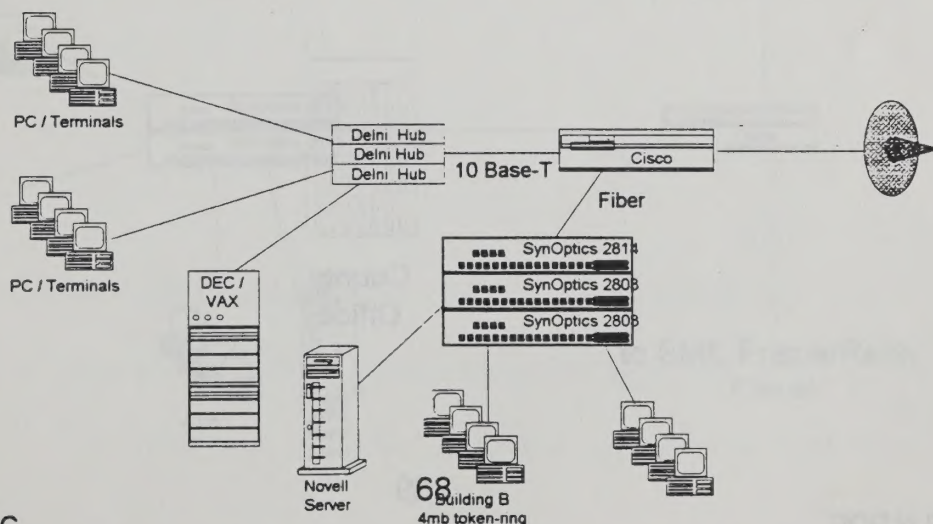
Migration Instructions

1. Configure & install Cisco 2514 router and replace the ACC 4200 (add a secondary IP address **128.7.200.1** on the VAX port). **NOTE: Block LAT traffic on the router serial ports !**
2. Change IP addresses in the DEC/VAX.
3. Change IP addresses on all necessary workstations.
(all workstations have to change at the time of the conversion)
4. Remove the secondary IP address from the VAX port.

Current



Transition / Future



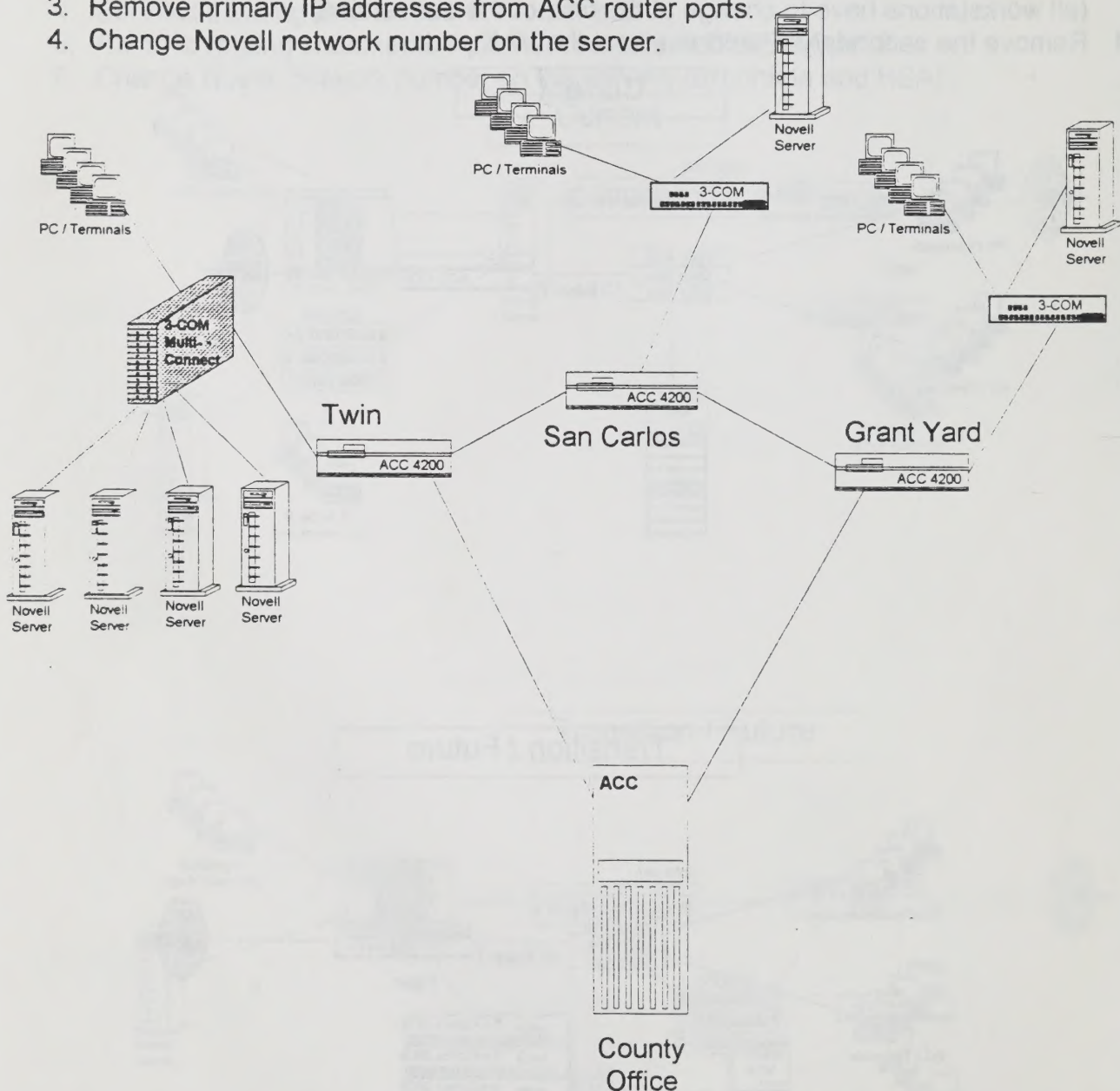
Public Works

(Includes : Twin Dolphin, San Carlos Airport & Grant Yard)

LAN Administrator: Tito Olazabal 1494

Migration Instructions

1. Add secondary IP addresses to ACC router ports 4200 & 4500.
Need to coordinate carefully !!!!!
2. Change IP addresses on all necessary workstations.
(all workstations have to change at the time of the conversion)
3. Remove primary IP addresses from ACC router ports.
4. Change Novell network number on the server.



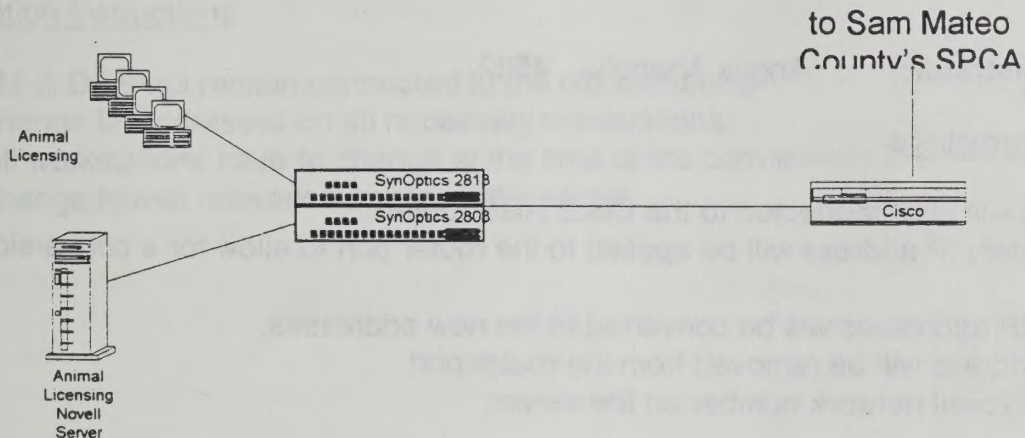
Animal Licensing / JTPA

LAN Administrator: Connie Urbanski 4840

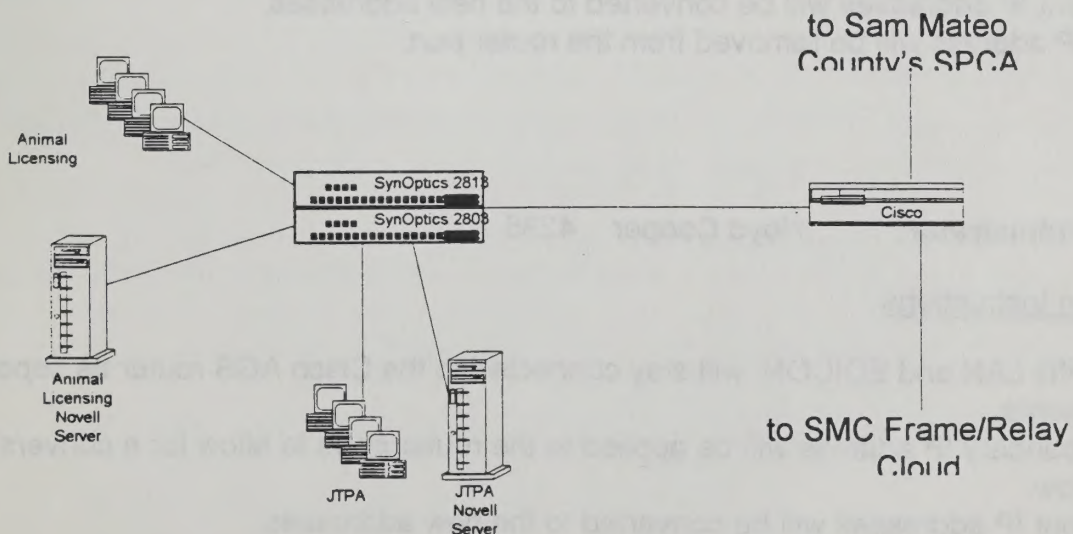
Migration Instructions

1. Install second DSU on the Cisco 4000 router port.
2. Configure second serial port for a frame/relay connection on the Cisco 4000 router.
3. Setup access lists on the router.
4. Change Novell network number on the server.

Current



Transition / Future



EPS / Purchasing

LAN Administrator: Belle Sierra 4329

Migration Instructions

1. EPS / Purchasing will stay connected to the Cisco AGS router.
2. A secondary IP address will be applied to the router port to allow for a conversion window.
3. Current IP addresses will be converted to the new addresses.
4. Old IP address will be removed from the router port.
5. Change Novell network number on the server.

Planning

LAN Administrator: Angus Ahanotu 4582

Migration Instructions

1. Planning will stay connected to the Cisco AGS router.
2. A secondary IP address will be applied to the router port to allow for a conversion window.
3. Current IP addresses will be converted to the new addresses.
4. Old IP address will be removed from the router port.
5. Change Novell network number on the server.

ISD

LAN Administrator: Carole Lawrence 4824

Migration Instructions

1. ISD network connection will be moved to the Cisco 7000 router.
2. A secondary IP address will be applied to the router port to allow for a conversion window.
3. Current IP addresses will be converted to the new addresses.
4. Old IP address will be removed from the router port.

Sheriff

LAN Administrator: Noyd Cooper 4235

Migration Instructions

1. Sheriffs LAN and EDICON will stay connected to the Cisco AGS router as separate segments.
2. A secondary IP address will be applied to the router ports to allow for a conversion window.
3. Current IP addresses will be converted to the new addresses.

4. Old IP address will be removed from the router port.
5. Change Novell network number on the server.

EDICON

EDICON is connected to the SynOptics 5000 hub should be connected to the Sheriff's segment (per Noyd).

911 / OES

LAN Administrator:	Joe Horton	OES	1296
	Robert Bustichi	911	4342

Migration Instructions

- 1 911 & OES will remain connected to the old backbone.
- 2 Change IP addresses on all necessary workstations.
(all workstations have to change at the time of the conversion)
- 3 Change Novell network number on the server.

ENTERPRISE NETWORK -- INITIAL STANDARDS

INTRODUCTION

Definition

For the purpose of this document the term **standards** are a set of specifications, or written guide lines, usually based on a set of agreed upon practices used for design and/or implementation planning. They lay out a strategic engineering structure of functional elements on which to develop consistent integratable network designs.

The standards provided in this document are focused on the work developed by the **Open Software Foundation (OSF)**, called **open systems standards**, that specify a set of industry-wide accepted rules to follow for interconnectivity, and interoperability. The objective of this kind of development is assure that any device or software can interoperate with any other device or software.

Where OSF standards are not complete, this document will use industry wide accepted practices for interconnectivity and/or interoperability. **This document is not complete, it is a beginning of development of a complete set of standards for the County of San Mateo Enterprise Network Architecture.** This document is a dynamic technical document that will change frequently as the needs of the business, and/or network change. Information in this document is as accurate only at the time of the publish date.

Preferred Hardware/Software

The hardware or software specified by manufacturer in this document are not the focus of this document and are not necessarily the only solution for open systems interoperability. They are provided as **preferred solutions on the basis of administrative and business needs established by the County of San Mateo Information Services Department** to simplify designs, reduce training requirements, reduce research complexity, improve purchasing power, or produce some other business benefit.

The Role of Standards

Standards are probably the most familiar component of open systems. They form the basis of such useful working features as portability and interoperability.

Using industry-wide standards in developing county network designs will ensure that hardware/software solutions used in the network will last longer and more likely be updatable as technology changes, thus getting more out of each dollar spent on the new network.

The Promise of Open Systems

Though Unix is the usual operating system of open systems and distributed computing, open systems are more than Unix applications. Today there are several solutions that support open system standards and work on a variety of operating systems and hardware platforms. Whatever solutions are chosen they must meet these objectives:

- *Allowing for innovation.* The purpose of open systems is not to achieve a technology where everything looks the same, but to establish an **atmosphere** where all kinds of information technology can work in unison.
- *A management role.* The **business view of open systems** must receive at least as much respect and attention as the technical definition. The main purpose of the technology is to serve the business client.

There are three major components a true open system should include:

- Products and technology based on established standards
- An open development infrastructure
- A solid management directive

Open systems represent other options. One of the most significant is as a downsizing option, PCs have gained ground recently with more powerful servers, native TCP/IP networking software on Intel based servers, and graphical user interfaces.

Whether based on Unix or Intel hardware, an even more important role for open systems is as the centerpieces of enterprise networks. Open systems are based on accepted, industry-wide standards. They reduce the need to manage diversity by reducing the diversity, although open system standards include links to other existing systems, both larger and smaller.

Standards and the Enterprise Network Strategy

The county network design staff will base the technical design specifications on the business requirements using Open System Standards and accepted industry-wide standards that assist in making design assumptions for the network.

Conceptual designs for the **Enterprise Network Architecture** expect to include these elements:

- Client/server platforms based on an open operating system.
- Routers, Hubs, ATM Switches, etc., that interconnect local area networks by:
 - Using UNIX based, Transmission Control Protocol/Internet Protocol (TCP/IP)
 - Using Intel based native TCP/IP LAN software

→ Using conversion/translation of IPX protocols for PC networks

- A platform to manage distributed computing and enterprise networks, based on industry accepted Simple Network Management Protocol (SNMP).

Open Systems and the Enterprise Network

A big reason for recommending open systems for the County of San Mateo Enterprise Network is the ability to support distributed computing. Distributed computing is at the heart of enterprise networking and client/server computing.

Open and distributed

That's why the movement to enterprise networking is also often a movement to open systems. The logic is simple: if a system is truly open, it knows no limits of geography. Ideally, access to computer in the next state should be no more difficult than access to a computer on the next desk.

In short, the open system can easily be a distributed open system, one that shares information and resources throughout the enterprise.

Benefits

- Open systems offer the promise to support distributed applications that will significantly enhance productivity throughout the organization.
- Open systems can improve productivity in significant ways compared with competing systems, they are more powerful, more responsive, or both, and they offer the benefits of multitasking.
- New faster desktop systems demand more from the servers or legacy systems that support them; OSI or TCP/IP based servers can help meet that demand.

NETWORK MANAGEMENT SYSTEM

Standard Network Management System requirements:

The standard definition of a County Enterprise Network Architecture conceptual end-to-end integrated **Network Management System** is one that:

Includes a unified end-to-end network view in a single window, but more importantly, integrates network management data from various Element Management Systems (EMSs) into a single database. Integration of data is a key to applying techniques such as expert systems, trend analysis, and graphical interfaces that provide problem management, identification/resolution, configuration, performance control, security, and accounting management end-to-end.

A standard for network management systems for the County Enterprise-wide Network Architecture ensures that the network manager equipment/software is compatible with open system standards (OSI) and the conceptual Integrated Network Management Model in this document.

Minimum functions must include end-to-end:

- An Integrated DataBase for expert systems
- Problem Management
- Configuration Management
- Change Management
- Performance and Accounting Management
- A single Graphical view of the entire network down to the Element level

Any new device/software (e.g., Telecom Facilities, Modems, CSU/DSU, Terminals, Routers, Host Computers, MUXs, etc.) must interface at one of the levels in the three tiered integrated hierarchy via SNMP, SNA, and non-SNA interfaces.

The provider of any network access device must demonstrate that the interface software is part of the device, meets open system standards, is upgradable, and will integrate easily with the existing county Enterprise-wide network management system.

Technical Requirements:

In developing a comprehensive network management model for the Enterprise Network we envision a well-balanced distributed system that will provide:

Integrated System manager, delegating to IASs and EMSs to manage the bulk of operational and problem determination functions. This system would handle functions that would be escalated to the Integration System by the IAS or EMS, or need additional levels of integration for synthesizing information from multiple IASs and EMSs for graphical views, rule based alarm correlation, expert system functions, trend analysis, and consolidated network management reports.

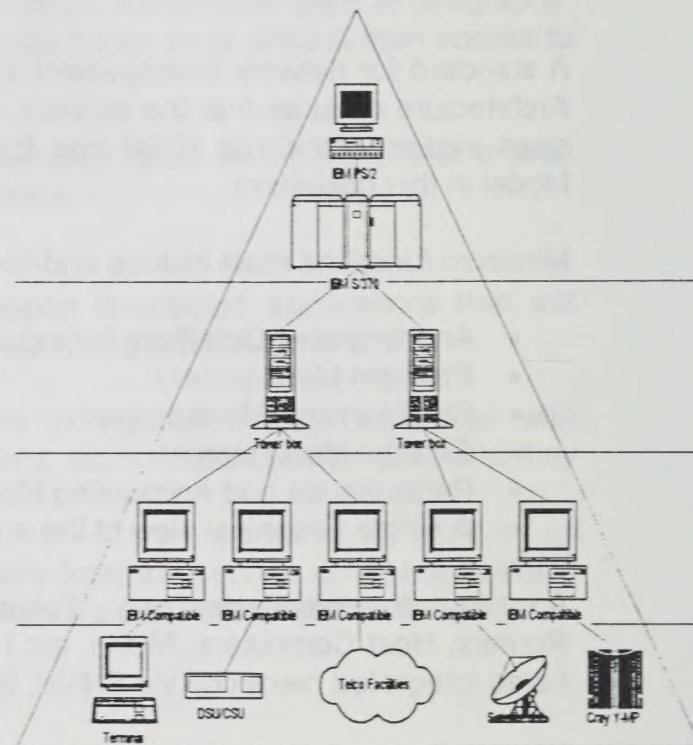
Conceptual Network Management Model:

Integration System Level - Collects information from IASs or EMSs for an integrated single view of the network. The integration system provides a single point for diagnostics and management across all EMSs. Configurable to integrate SNA and non-SNA elements, such as Peregrine-PNMS.

Intermediate Aggregation Systems (IAS) Level - A system that can integrate data from multiple devices into a single database, such as NetView/6000 or HP OpenView.

Element Management Systems (EMSs) Level - A system that manage subsets of network elements, such as IBM LAN Mgr., Novell NMS, CiscoWorks.

Network Elements Level - These are basic network elements (OSI & SNMP objects are abstractions of these elements), such as Telecom Facilities, Modems, CSU/DSU, Terminals, Routers, Host Computers, MUXs, etc.



Background:

On the basis of a complete network management system, the key point to be made is that no current single network management software provides end-to-end Enterprise-wide Network Management at all levels. Therefore, a hierarchy of network management software linked together to form a comprehensive and complete end-to-end management diagnostics and control at all levels of the network is required.

In moving toward the conceptual Enterprise-wide Network Management system for end-to-end network management the county may pass through three basic migrations of network management environments:

1. **Centralized Systems** - Simply a centralized location where various EMS consoles are terminated without regard to provision of an integrated view or data for network management or reporting.
2. **Consolidated Systems** - A single consolidated workstation from where an operator can access individual element management systems. Typically, it is represented by a multiple windowed environment where each EMS is set up in a separate session. The operator can select a window and EMS to manage different segments of the network. Usually this workstation is a multitasking, GUI-based operating system such as UNIX/AIX or OS/2.
3. **Integrated System** - This type of network management system integrates the network view into a single window and provides an integrated database to manage, control, and report on the network end-to-end. This may be a Host based management system or on separate processors. Although not available today, this type of network management will most likely be a multi-tiered distributed network monitoring system. In a multi-tiered environment the work load of remote monitoring, alarm filtering, and system status/control can be delegated to the network management element closest to the source.

Business Requirements:

The County has just recently begun to incorporate new technologies into the existing network, and is in the process of developing a new Enterprise Network Architecture plan. The County business partners have also just begun to implement client/server systems into the current network infrastructure. With the new knowledge, technology, and business requirements the need to develop a coherent network management strategy has become necessary.

The County currently uses Netview as the network manager for the SNA environment. The County of San Mateo is currently an IBM based environment with SNA as a predominant protocol, and a network that is a disparate mix of topologies with a variety of network management relationships. It is not likely that the SNA environment will go away in the near term, or that the network will be totally TCP/IP and SNMP dedicated in the long term. On the basis of this mix of system environments in the future the county

needs to develop a comprehensive network management model that will support all of the network end-to-end.

Analysis of Preferred Products:

The following products were reviewed in anticipation of more TCP/IP networks within the Enterprise Network Architecture as network manager systems:

At the Integration System Level:

- Peregrine/PNMS

At the Intermediate Aggregation System (IAS) level:

- Netview/6000
- HP OpenView/NNM
- SunNet Manager/SNM

Integration System Level:

The Peregrine/PNMS network management system is a suite of software packages that captures and integrates data from various aggregation and element management systems. PNMS is the only known current product that incorporates all of the following:

- Integrated database for expert systems
- Problem management
- Configuration management
- Change management
- Performance and Accounting management
- Provides all information in a single graphical user interface view

Peregrine/PNMS review provided the following analysis of the PNMS "software suite":

- PNMS provides SNA network management via "OpenSNA" that detects the failure, sends the alert to "IPAS", automatically opens a ticket, reports failure to PNMS, identifies the technician, and sends a dispatch via "AXCES" to the technician.
- On user calls, PNMS collects user information via help desk operator, then uses "COVER" to locate the user device and identify the problem.
- On user calls for SNA application problems, PNMS uses "Session Recap", a session capture option, to retrace the session key strokes of the user and identify the problem.
- For LAN network management, PNMS uses "StationView" and "ServerView" to look into the LAN to identify failed hardware/software.

Advantages:

1. Off the Shelf Plug-and-Play
2. Large installed base
3. Well accepted in the industry
4. Provides the widest acceptance of various network types and element inputs
5. Meets almost 100% of the county network objectives
6. Peregrine system works with UNIX, MVS, and Novell systems
7. Peregrine Systems company is actively involved in developing Open Systems solutions, Client/Server solutions, and Porting of products across all platforms
8. Peregrine Systems products are used in every segment of the Fortune 500 companies, and is used in over 50% of the Fortune Global 50 companies

Disadvantages:

1. Requires extensive inventory of non-SNMP objects
2. Very little competition from other vendors
3. Limited competitive price pressure
4. Does not current support Windows/NT LAN software

The County of San Mateo Information Services Department has selected Peregrine as the preferred product for the Integration System Level of network management.

Intermediate Aggregation Level:

The intermediate aggregation level provides the interface for various LANs, MUXs, or Element Management Systems (EMSs). The three systems reviewed provided the following analysis:

- **HP OpenView/NNM** - HP OpenView was originally introduced as a development platform and then later complimented with the HP Network Node Manager (NNM) software completing OpenView as a plug-and-play end-user network management product. HP OpenView supports Motif GUI, the latest in graphical user interfaces that allows users to create views with subsets of the network for different tasks.

Advantages:

1. Off the Shelf Plug-and-Play, no additional software development required.
2. Available on multiple platforms - HP, SUN, and DOS/Windows.
3. Second only to SunNet Manager in number of third party network management applications.

Disadvantages:

1. Applications written on one platform will not work on another.
2. Unnecessary windows cause confusion and clutter for operator on screen presentations.
3. Does not closely support SNA, DECnet, X.25, carrier services, modems, facility management systems, or non-SNMP multiplexers and switches.

4. Do not appear to have a clearly defined vision of the Enterprise Network Management system of the future. May not develop an end-to-end solution for network management.

- **SunNet Manager (SNM)** - SNM is primarily intended as a development platform, however due to this it has extensive third party network management applications developed on this platform and has the largest installed base. SNM is also the oldest of the network management systems and as such is an aging system. Sun has yet to plan a major upgrade to the system and its future is unknown.

Advantages:

1. Largest installed base of users.
2. Largest number of third party applications.
3. Strong tool kit for developers for customized applications development.
4. Lowest cost of all SNMP network management systems.

Disadvantages:

1. No auto-discovery capability, operator must initiate manual query of network issues.
 2. No Motif GUI capability for customized graphical user interface.
 3. More complex operator interface requiring more effort from operator to access network information.
 4. SNM is not plug-and-play, extensive custom programming is required to achieve a level of functionality similar to HP OpenView or Netview/6000.
- **Netview/6000** - Under a license agreement with HP, IBM obtained the rights to enhance HP NNM and brought its own version to the market in the form of Netview/6000. The enhancements are significant and have positioned IBM as a major contender for the leading spot in SNMP network managers. IBM has the rights to use future updates to NNM and continue to use the latest version to continually enhance its own position in the market place. Of all the network managers Netview/6000 is the easiest software to install, has the best user interface presentation, is the simplest to use, and is the most compatible with SNA and other non-SNMP network management software. Netview/6000 works seamlessly with Netview/390, providing the capability to build a hierarchy of integrated network management environments.

Advantages:

1. Simplest to install with user point and click installation instructions on screen.
2. Motif supported GUI, with tool palette for operator to customize display presentations in ICONS.
3. Automatic discovery of alarm/problem issues on network with graphical display of issues.
4. Presentation "event cards" that provide point and click operator help on how to resolve the problem.

5. Powerful "Control Desk" feature to launch applications into ICONS or Windows for multitasking operations.
6. More flexible ways to define alarm filters and alert processing.
7. Ability to script and invoke any UNIX supported command.
8. Works seamlessly with Netview/390, can support SNA, and non-SNMP inputs.
9. The Netview/6000 evaluated by the County of San Mateo communications staff is compatible with the conceptual model described in this document.
10. Netview/6000 provides OSI compatibility with SystemView, a framework to support OSI standards.

Disadvantages:

1. Fewest third party applications of the three major network manager vendors.
2. Netview/6000 can only run on a RS/6000 platform.
3. Cannot be un-bundled from developer's kit, although priced less than HP OpenView with Developers kit.

Recommendation of Preferred Product:

The proposed Network Managers at all levels must be compatible with OSI and the conceptual Integrated Network Management Model shown below, delegating to IASs and EMSs to manage the bulk of operational and problem determination functions. The Integrated Systems Level Manager must handle functions that would be escalated by the IAS or EMSs, and pass data between levels of integration for synthesizing information from multiple IASs and EMSs in a single graphical view using, rule based alarm correlation, expert system functions, trend analysis, and consolidated network management reports.

The Network manager must be compatible with SNMP, SNA, non-SNMP, support DECnet, X.25, carrier services, modems, facilities management systems, multiplexers, and switches.

Preferred Products:

Peregrine/PNMS - As the Integrated Systems Level Network Management system.

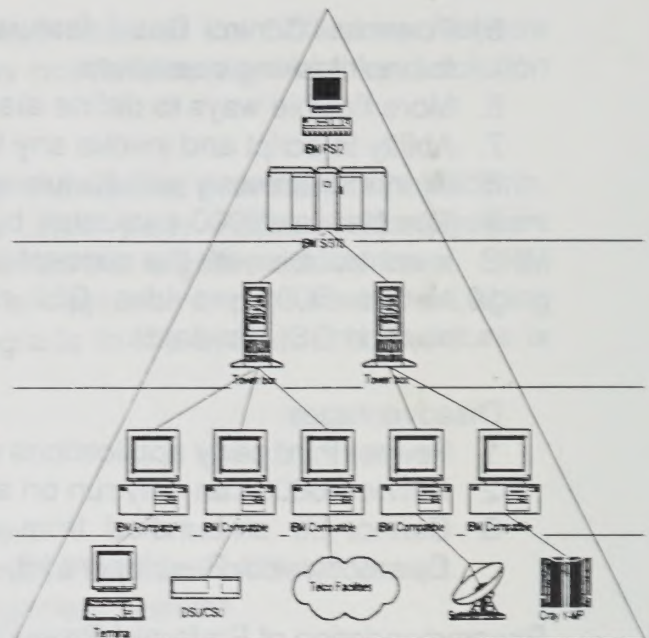
Netview/6000 - As the Intermediate Aggregate System level management system.

Element Solutions - Based on the vendor and network management software provided by the vendor.

Peregrine/PNMS - Preferred product for integration of systems management solutions including, SNA System management, providing a single integrated view and delegated management functions.

Netview/6000 - Preferred product for the intermediate aggregation system is OSI compatible, collects SNMP, SNA, and non-SNA inputs, filters alarms and alerts, combines EMS level and passes data/alarm functions up to Integrated Systems Level.

IBM LAN NetMan, LattisView, Novell NMS, CiscoWorks, etc. - Vendor provided Element Management systems that report events up to the Netview/6000 intermediate aggregation system.



Benefits:

The benefits of the standard network management concept specified here are:

- Consistent development of network management hierarchy that leads to an integrated display, control, and reporting of end-to-end network issues.
- Seamless management at all levels of the network infrastructure, and for all topologies.
- A planned network management strategy that requires vendors to meet our specifications for network management interfaces.
- Cost advantages by incorporating new network hardware/software management schemes into the known network management hierarchy. Reducing the need to add network management hardware/software to support new network additions.
- Consistent operator interfaces that reduce the need to train on various network monitoring software.
- The ability to identify problems quickly without on-site trouble analysis, limit on-site visits to repair only, and provides remote resolution to many network problems. Improves reporting capability to management and clients.
- Provides for expert systems for trend analysis, capacity management, network development, management reporting, historical reporting, trouble analysis, problem cost analysis, and accounting reporting.

NETWORK/UTTER EQUIPMENT

- Moving toward open standards insures the County of system compatibility in the future as new technology is released, thus gaining full life cycle aging for installed technology.

The router must support the County of San Diego Department of Information Technology Architecture and support the Local Area Network protocols SNA, TCP/IP, NetBIOS, IPX/SPX, DECnet, and others. The router must also support the Wide Area Network of Frame Relay (FRL), Integrated Services Digital Network (ISDN), Asynchronous Transfer Mode (ATM), and others. The router must support Service (RAS), and Synchronous Optical Network (SONET).

The Router must support open system standards (OSI) model for network configuration and network management, and must be able to interface to existing software.

The vendor must be a proven reliability provider of products for Enterprise Networks, and have a strong technical background and product with a worldwide market share in the industry.

Technical Description

The Router is a multi-processor device that supports the OSI model and provides installation for the new networking LAN protocols.

The Router must also support and interface with WAN protocols, and must be able to interface with a variety of hardware, software, and network options. The ability to interface with a variety of Router management is required.

The product must be software controlled with the ability to update the software to increase capacity, upgrade capability, or add new software and hardware (e.g., ATM). The product must be modular in design with options to plug in additional ports or functionality.

The Router must be able to support SNMP network management. The Router must be capable of remote configuration and support open system network management tools.



NETWORK ROUTER EQUIPMENT

Standard Router requirements:

The preferred Routers in the County of San Mateo Enterprise-wide Network Architecture must support the Local Area Network protocols SNA, TCP/IP, NetBIOS, IPX/SPX, DECnet, AppleTalk, Bridging, FDDI, and IBM APPN. The Router must also support the Wide Area Protocols of Frame Relay (F/R), Integrated Services Digital Network (ISDN), Asynchronous Transfer Mode (ATM), Switched Multimegabit Data Service (SMDS), and Synchronized Optical Network (SONET).

The Router must support open system standards (OSI), provide for remote configuration and network management, and keep up with technology by upgraded software.

The vendors must be a proven industry provider of Routers for Enterprise Networks and have a stable financial background and product with a reasonable market share in this industry.

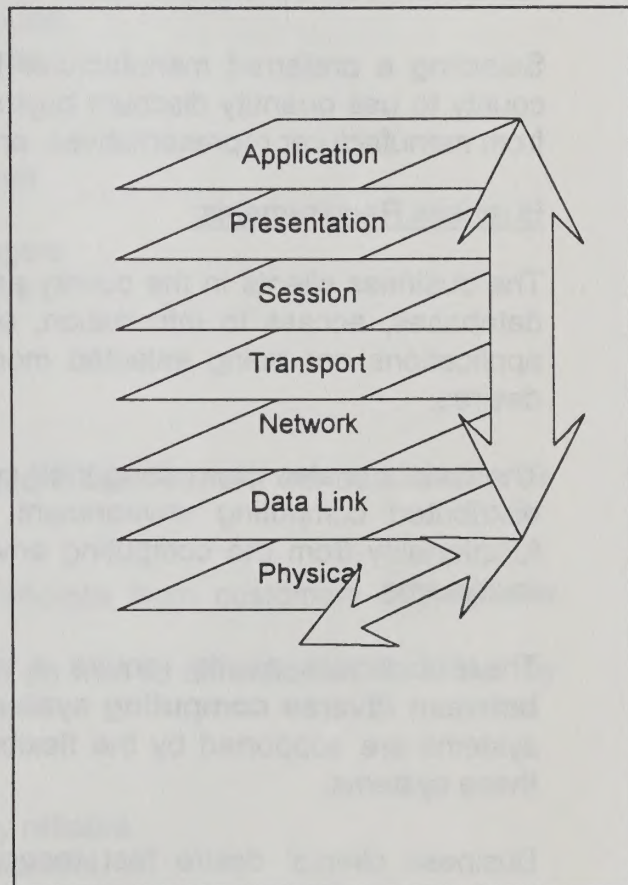
Technical Requirements:

The Router as a internetworking device must support the OSI seven layer model and provide translation for the major internetworking LAN protocols.

The Router must also support and interface with WAN protocols listed in this document. Provide interoperability with a variety of hardware, software, and network solutions. The ability to interoperate with a mix of Router manufacturers is required.

This product must be software controlled, with the ability to update the software to increase capability, upgrade operability, or keep pace with emerging technology (e.g., ATM). The product must be modular in design, with capability to plug-in additional ports or functionality.

The Router must be able to support SNMP network management. The Router must be capable of remote configuration with standard open system network management tools.



Background:

A Router connects dissimilar LAN and WAN systems together by using address tables and protocol conversion to pass and encapsulate data to remote locations. The Router provides connectivity, bridging, routing, and translation to link network segments together.

The San Mateo County data communications network is expanding in size, traffic, and complexity. The Enterprise Network Architecture plan is moving in the direction of open systems to provide a standardized base of concepts to allow for the expected growth. The Jail project and the FMS project are examples of growth projects that require additional hardware and software. Both of these projects exposed the county staff to new technology. In expanding the data network more diverse computing systems and environments must talk to each other over the WAN and backbone.

The county currently uses several types of Routers. When Routers from different manufacturers cannot interface with proprietary protocols to talk to each other they must use a basic protocol called point-to-point protocol (PPP). This is an inefficient protocol and is not as effective as the proprietary protocols used within a manufacturer's product line. Therefore it is more effective to select a manufacturer that can be used as a preferred Router for the county-wide network.

Selecting a preferred manufacturer has other benefits for the future. It allows the county to use quantity discount buying, requires less training, leverages more support from manufacturer representatives, and simplifies the network design.

Business Requirements:

The business clients in the county are developing a desire to have more control over databases, access to information, and operator display presentation. Client/server applications are being selected more often by the business client to support their desires.

The county is also downsizing their computing environment, and this usually leads to a distributed computing environment. Business clients are also looking for more functionality from the computing environment including imaging, video, and perhaps multimedia.

These business needs require **a robust network that provides interoperability between diverse computing systems**. The interconnectivity between these diverse systems are supported by the flexibility of Routers to connect, translate, and bridge these systems.

Business clients' desire fast response to network design requests driven by the business changes in the communications and computing environment. Business clients require solutions that work, are transparent to the user, provide flexibility in supporting business changes, and are supportable by the technical staff.

Analysis of Preferred Products:

The following Router products were reviewed in anticipation of more TCP/IP networks within the mix of network hardware/software in the Enterprise Network Architecture:

1. Advanced Computer Communications (ACC)
2. Cisco Systems
3. IBM Corporation
4. Novell
5. Proteon
6. 3Com Corporation
7. Wellfleet Communications

The staff conducted product evaluations on the routers listed above and reviewed information documenting recent independent surveys of customers who use a variety of Router equipment:

The Router evaluations were based on the following criterion:

- Reliability
- Speed of Data throughput
- Supports widest range of network protocols
- Supports widest range of WAN Interfaces
- Best track record
- Best technical support
- Supports widest range of wiring schemes
- Best support for SNA traffic
- Ease of configuration of network managers
- Ease of installation of network managers
- Price advantage
- Best documentation
- Best value for the price

The summary of the survey and evaluations rated Cisco Routers the best choice as shown below:

1. **Cisco and Novell** are the most likely choices from customers buying new equipment.
2. **Cisco was rated the best overall** based on the 13 attributes listed above by industry-wide customers who use Routers.

Advantages:

1. Equipment is well made and has been very reliable.
2. The staff has been well trained on the equipment.
3. The Cisco company has been very responsive to any support issue.
4. The brand is well known in the industry and information on the product and usage is well documented.

5. The equipment supports all the known applications/topologies planned by the county.
6. Training requirements are reduced

Disadvantages:

1. By choosing a single manufacturer, price competition may be lost
2. County has a mix of Routers now, interfacing dissimilar routers is complex and inefficient.

Recommendation of Preferred Product:

The proposed Router must be compatible with the following:

- ⌚ A Router that meets or exceeds all requirements set out in OSI, and stated in this standard.
- ⌚ A widely accepted Router based on industry market statistics and customer satisfaction on the basis of customer survey's listed above.
- ⌚ A Router manufacturer that has demonstrated that future Router applications will be addressed and have a clear vision to support emerging technologies.

Preferred Product:

Cisco Family of Routers - Met or exceeded the above criterion, and provide the best support for current and planned network solutions for the County of San Mateo proposed in the Warner Group Enterprise Network Strategy.

Cisco Router Series 2xxx, 4xxx, 7xxx.

- ⌚ Cisco 2xxx Family Router - A stand-alone non-slotted Router primarily designed for small single LAN remote sites. Supports 1-local area port, and 1-4 wide area ports.
- ⌚ Cisco 4xxx Family Router - A three slot modularized Router capable of combining several LAN/WAN interfaces and protocols.
- ⌚ Cisco 7xxx Family Router - A five slot modularized Router with redundant power supplies capable of supporting a large variety of LAN/WAN interfaces. This series of Router is scalable by loading slots as necessary for the current networking environment and adding processor cards when required.

Benefits:

- ① Consistent Router deployment in the enterprise-wide network that leads to an integrated consistent network Router configuration that simplifies design, training, configuration, and network management.
- ① A planned network strategy that requires vendors to meet our specifications for network Router interfaces.
- ① Cost advantages by incorporating known network hardware/software schemes into the network, reducing the need to provide network hardware/software training to support the network additions.
- ① Consistent operator interfaces that reduce the need to train or become familiar with various network configuration/operation software.
- ① Provide for expert systems for trend analysis, capacity management, network development, management reporting, historical reporting, trouble analysis, problem cost analysis, and accounting reporting through SNMP.
- ① Moving toward open standards compatible hardware/software insures the County of system compatibility in the future as new technology is released, thus gaining the full life cycle for installed technology.

Technical Requirements

The interconnecting Hub must support the CDD when they are used.

The Hub must provide interoperability with a variety of hardware schemes, and network software. The ability to interface with a mix of hub configurations is required.

The product must be software controlled, with the ability to update the software to include capacity, upgrade operating, or other new software technology as it is available. The Hub must be modular in design, with capability to plug in a new piece of hardware.

The Hub must be able to support SNMP network management. The Hub must be capable of remote configuration with standard data system network management.



NETWORK HUB EQUIPMENT

Standard HUB requirements:

The standard for Hubs in the County of San Mateo Enterprise-wide Network Architecture must support the Local Area Network Ethernet, FDDI, and Token Ring systems. The Hub must support the following functionality:

- ✱ Flexibility in network configuration, separating the physical from the logical network.
- ✱ Support user applications such as fax and directory services.
- ✱ Support the ability to link mixed networks, including other LANs, or remote offices.
- ✱ Interchangeable modules to fit different types of networks.
- ✱ Support the ability to handle multimedia applications.
- ✱ Support emerging technology such as Asynchronous Transfer Mode (ATM).

The Hub must support open system standards (OSI), provide for remote configuration and network management, and keep up with technology by upgraded software.

The vendors must be a proven industry provider of Hubs for Enterprise Networks LANs and have a stable financial background and product with a reasonable market share in this industry.

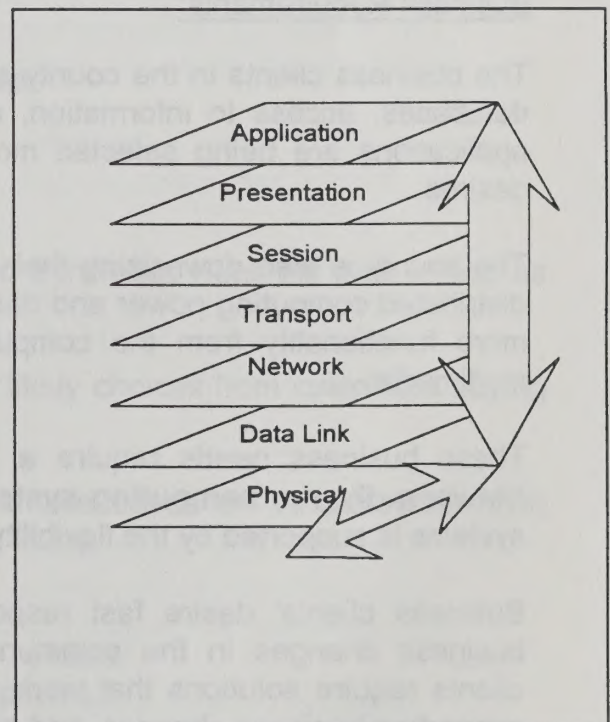
Technical Requirements:

The internetworking Hub must support the OSI seven layer model.

The Hub must provide interoperability with a variety of hardware, software, and network solutions. The ability to interoperate with a mix of hub manufacturers is required.

The product must be software controlled, with the ability to update the software to increase capability, upgrade operability, or keep pace with emerging technology (e.g., ATM). The Hub must be modular in design, with capability to plug-in additional cards for functionality.

The Hub must be able to support SNMP network management. The Hub must be capable of remote configuration with standard open system network management tools.



Background:

A Hub distributes LAN systems by providing connectivity and translation to link network segments together.

The San Mateo County data communications network is expanding in size, traffic, and complexity. The Enterprise Network Architecture plan is moving in the direction of open systems to provide a standardized base of concepts to allow for the expected growth. The Jail project and the FMS project are examples of growth projects that require additional hardware and software. Both of these projects exposed the county staff to new technology. In expanding the data network more diverse computing systems and environments must talk to each other over the LAN, WAN, and backbone.

The county currently uses several types of Hubs. This creates complexity in the network, and increases training requirements. In the desire to be more effective in designing and managing Hub systems the county staff has decided to select a manufacturer that can be used as the preferred product for the county-wide network. Using a preferred product simplifies the network and reduces the training required for staff. Using a preferred product also reduces the time between requested design and actual implementation for the client by using known products that require less research.

Selecting a preferred manufacturer has other benefits for the future. It allows us to use quantity discount buying, leverages more support from manufacturer representatives, and simplifies the network design.

Business Requirements:

The business clients in the county are developing a desire to have more control over databases, access to information, and operator display presentation. Client/server applications are being selected more often by the business client to support their desires.

The county is also downsizing their computing environment, and this usually leads to distributed computing power and databases. The business clients are also looking for more functionality from the computing environment including imaging, video, and multimedia.

These business needs require **a robust network that provides interoperability between diverse computing systems**. The interconnectivity between these diverse systems is supported by the flexibility of Hubs to connect these systems.

Business clients' desire fast response to network design requests driven by the business changes in the communications and computing environment. Business clients require solutions that work, are transparent to the user, provide flexibility in supporting business changes, and are supportable by the technical staff.

Analysis of Preferred Products:

The following Hub products were reviewed in anticipation of more TCP/IP networks within the mix of network hardware/software in the Enterprise Network Architecture:

1. Cabletron
2. SynOptics Systems
3. IBM Corporation
4. Ungermann-Bass
5. Chipcom
6. 3Com Corporation
7. David Systems
8. Hewlett-Packard

The staff conducted product evaluations on the Hubs listed above and reviewed information documenting recent independent surveys of customers who use a variety of Hub equipment:

- ✱ The Hub evaluations were based on the following criterion:

Reliability

Most compatible with other Hubs

Supports widest range of wiring schemes

Supports widest range of LAN operating systems

Best track record

Best technical support

The most expandable

Ease of installation of network managers

Price advantage

Best documentation

Best value for the price

The summary of the survey and evaluations rated SynOptics Hubs the best choice as shown below:

1. **SynOptics and Cabletron** were the most likely choices from customers buying new equipment.
2. **SynOptics was rated the best overall** choice based on 11 attributes listed above by industry-wide customers who use Hubs.

Advantages:

- ✱ Equipment is well made and has been very reliable.
- ✱ The staff has been well trained on the equipment.
- ✱ The SynOptics company has been very responsive to any support issue.
- ✱ The brand is well known in the industry and information on the product and usage is well documented.

- ✱ The equipment supports all the known applications/topologies planned by the county.

Recommendation of Preferred Product:

The proposed Hub must be compatible with the following:

- ✱ A Hub that meets or exceeds all requirements set out in OSI, and stated in this standard.
- ✱ A widely accepted Hub based on industry market statistics and customer satisfaction on the basis of customer survey's listed above.
- ✱ A Hub manufacturer that has demonstrated support for most LAN operating systems and future Hub applications will be addressed with a clear vision to support emerging technologies.

Preferred Product:

SynOptics Family of Hubs - Met or exceeded the above criterion, and provide the best support for current and planned network solutions for the County of San Mateo based on the Warner Group Enterprise Network Strategy.

SynOptics Network Management Module (NMM) 5000 Series, a chassis incorporating a multi-part back-plane that consists of the following functional elements:

- ✱ SynOptics Ethernet NMM - A stand-alone Hub card designed for Ethernet local area networks. Supports standards for 10BASE-T, IEEE 802.3 over twisted pair; 10BASE2, IEEE specification over thin coaxial cable; and 10BASE5, IEEE 802.3 over thick coaxial cable.
- ✱ SynOptics Token Ring NMM - A stand alone Hub card designed for Token Ring local area networks. Supports token-passing LAN consistent with IEEE 802.5 standard.
- ✱ SynOptics FDDI NMM - A stand alone Hub card designed for Fiber Distributed Data Interface (FDDI). Supports dual-ring architecture and all protocols supported by FDDI.

Benefits:

- ✱ Consistent Hub deployment in the enterprise-wide network that leads to an integrated consistent network Hub configuration that simplifies design, training, configuration, and network management.
- ✱ A planned network strategy that requires vendors to meet our specifications for network Hub interfaces.

- ✱ Cost advantages by incorporating known network hardware/software schemes into the network, reducing the need to provide network hardware/software training to support the network additions.
- ✱ Consistent operator interfaces that reduce the need to train or become familiar with network configuration/operation software.
- ✱ Provide for expert systems for trend analysis, capacity management, network development, management reporting, historical reporting, trouble analysis, problem cost analysis, and accounting reporting through SNMP.
- ✱ Moving toward open standards compatible hardware/software insures the County of system compatibility in the future as new technology is released, thus gaining the full life cycle for installed technology.

Barriers to success

One reason to not to migrate to more sophisticated systems is the support available from some critical day-to-day systems. These systems tend to be running while migrating to other solutions. This support often comes up and sets back even the most advanced environment for which it was never designed.

Businesses need designed open systems now, but they are not ready to do so, and to keep from losing the ability. A company will create and use systems to restrain them.

Frictioned by the County, many business owners have been reluctant to take their own hands. Their response has been to wait for a better solution.

D. Forming their own business networks. This is a group and using their own specifications without waiting for a better solution.

D. Purchasing vendors who can show their results now, though they do not offer proprietary systems.

Either response can be a necessary compromise or a dangerous pitfall. Is the first plan the best with an open mind toward the County's ultimate goals?

Risks:

Many factors can make a project fail. They can be identified as risk factors for which known can be countered by avoiding them. The following identified risks are not all inclusive. They should be used as a starting point for thinking about potential problems and developing an implementation.

RISKS FACTORS:

Success Factors:

Success of the enterprise network architecture development relies upon:

- Management support for open standard based solutions to business requirements.
- A county design strategy that follows the plan.
- A set of guidelines or standards to follow in implementing new technology.
- Buy-in from senior county management and all business clients.
- Development of standards based on Open Software Foundation (OSF) and de facto industry standards.

Barriers to success

One reason it's hard to migrate to more cost-effective systems is that legacy applications often serve critical day-to-day functions. They must be kept up and running while migrating to other solutions. This software often does not work well in an open, client/server environment for which it was never designed.

Businesses need distributed open systems now, to capitalize on business opportunities and to keep from being left behind. A continuing lack of tools and applications often restrain them.

Frustrated by the delays, many business organizations have taken matters into their own hands. Their responses follow two main patterns:

- ☐ Forming their own business-sponsored standards' groups, and setting their own specifications without waiting on the more conventional process.
- ☐ Patronizing vendors who can meet their needs now, though they do so with proprietary systems.

Either response can be a necessary compromise or a dangerous pitfall. Is this a well planned step with an identified migration path toward the County's ultimate goals?

Risks:

Many factors can make a project fail. They can be identified as risk factors that once known can be countered by avoiding them. The following identified risks are not all inclusive. They should be used to stimulation thinking when detailed designs are developed for implementation.

High Risk:

1. The County culture in ISD is mainframe oriented and this orientation can delay needed migration toward a distributed network environment.
2. The County does not have much experience with distributed networking.
3. Management decisions require complex and difficult processes through several levels of the management hierarchy to get consensus on networking direction.
4. The budget process in the County raises issues of ownership on network equipment, access to equipment, and options included with equipment orders.
5. There is no clear demarcation between the network backbone equipment and services, versus the department network and service.
6. The County may not budget for the Enterprise Network implementation project.

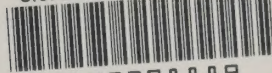
Medium Risk:

1. Standards or guidelines developed by the ISD networking staff are not well accepted by the various agencies throughout the County.
2. Departmental management throughout the County tend to develop their own network plans without consultation from ISD.
3. The use of the Microwave system as the primary backbone for the Enterprise Network is a departure from the traditional use of the system by Public Service Radio.

Low Risk:

1. All protocols may not be integratable with current router technology.
2. The staff may not be experienced enough to implement the network as planned.
3. The Enterprise Network Strategy may need updating by the time a project is developed and budgeted to implement the network.

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